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Accelerating Africa's Food Production in Response to Rising Food Prices

Impacts and Requisite Actions

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ABSTRACT

In Africa the global food crisis threatens the livelihoods of millions of people who because of high rates of poverty, hunger, malnutrition, and food dependency are already exceptionally vulnerable. In better circumstances, Africa's agricultural sector would respond to rising prices by increasing food supply. But such a response is impossible without significant new policy actions on both the production and marketing of African agriculture. This paper assesses the likely impacts of two strategic policy options: doubling African staples production, and improving "market access" through regional integration and lowering transaction costs. Using an economywide multimarket model for 17 African economies and econometrically estimated parameters describing the relationships between growth and poverty and between public spending and growth, we assess the impacts of these two strategic options on Africa's food markets and its broader economic development.

Doubling staples production significantly increases food security, reduces consumer food prices by roughly 25 percent, reduces producer prices by 10 percent (thus raising farm revenue), accelerates agricultural growth rates, facilitates broader economic growth through new agroprocessing and export opportunities, and lifts more than 100 million Africans out of poverty. Key policy actions are needed to move from this strategic vision to implementation. The first set of actions requires investing $38 billion from 2009 to 2013, or $7.5 billion per year, in a well-designed package of modern agricultural inputs and provisions. The second requires improving and extending transport infrastructure, especially major transport corridors and rural feeder roads. The third requires reducing tra*de barriers, which still remain much higher in agriculture than in other sectors. All of these actions are technically and financially feasible, but their timely implementation requires urgent initiatives by both national and international policymakers.

Keywords: food prices, Africa, green revolution, staples, agricultural productivity, market access, infrastructure, economic modeling

1. INTRODUCTION

The All Important Price of Food

In Africa a typical family spends between 50 and 70 percent of its budget on staple foods. Surges in the price of food in this region can therefore make the difference between life and death, between health and sickness, between peace and violence, between progress and poverty. Since 2003 world maize and wheat prices have more than doubled. The price of rice has jumped to unprecedented levels, doubling in the first four months of 2008 (von Braun et al. 2008). Although food prices have come down somewhat at the global level, they remain very high in many countries, particularly in Africa. A recent World Bank study suggests that this surge in prices could plunge 105 million more people worldwide—many of them Africans—into poverty (Ivanic and Martin 2008). As local markets in Africa begin to feel the effects of international price surges (see Box 1, Panel D), food riots and protests in several African countries are becoming commonplace, suggesting that many Africans are already suffering. Other impacts—such as the effects of food-induced inflation and deteriorating trade deficits—on economic growth, as well as the impact of childhood malnutrition on children's health and education, will be felt only in the years to come. Several studies have also suggested that, unlike the 1974 food crisis, the current crisis may be characterized by higher real food prices for many years to come (OECD/FAO 2007; USDA 2008; von Braun 2008).

In better circumstances, rising food prices should ideally induce African farmers to produce more, thus helping to solve the food crisis. But two decades of declining international food prices between 1980 and 2000 have been accompanied by the neglect of African agriculture among African policymakers and development partners. For example, foreign assistance for agricultural development in Africa declined by around two-thirds in absolute terms in that period (Bezemer and Headey, 2008). Similarly, African governments reduced their share of budgetary allocations for agriculture from an already low level of 5 to 10 percent in the 1980s to an extremely low level of 3 to 5 percent in the 1990s (Fan and Rao, 2004). This means that during the 1980s and 1990s many African governments have spent less than $20 annually per farmer on agricultural development, rarely enough to mitigate the taxes on small farmers directly and indirectly imposed by those same governments (Bezemer and Headey 2008; Schiff and Valdes 1992).

With such meager support it is hardly surprising that African farmers have experienced stagnating yields and economic marginalization (Box 1, Panel A). No less surprising are the broader impacts of this stark neglect of African agriculture. A third of Africans suffer from malnutrition, 43 million from chronic hunger. Countries with significant amounts of fertile land are increasingly vulnerable to declining soil quality and climate change. Economies with a comparative advantage in agriculture have become increasingly dependent on cereal imports and food aid (Box 1, Panel B). And now the neglect of African agriculture is about to prove still more costly, as the ability of the continent's smallholders to respond adequately to rising food prices is severely limited by underinvestment, poor infrastructure, rising energy and fertilizer prices, and persistent barriers to regional and international trade.

In the face of surging food prices, the urgency of dealing with the crisis will require some immediate steps by African governments and donors, including expanding emergency responses and humanitarian assistance to the food insecure, undertaking fast-impact food production programs in key areas, and scaling up investments for sustained agriculture growth, among others (see von Braun et al. 2008 for more details). The focus on revitalizing the agricultural sector is especially critical for several reasons. In addition to its immediate impact on food security, agriculture is still the largest source of employment for Africans, and it remains a lead sector of comparative advantage (Diao et al. 2007; Diao and Dorosh 2007). Moreover, agricultural productivity growth has repeatedly been shown to be the primary driver of global poverty reduction (Christiaensen, Demery, and Kühl 2006; Thirtle, Lin, and Piesse 2003; Byerlee, Diao, and Jackson 2005; Bezemer and Headey 2008), both through its direct effects on farmers' incomes, as well as its indirect effects through the reduction of food prices. The sector also has tremendous growth potential when the right policies are in place. In the early 1960s rising poverty, increasing dependence on food aid, and severe population pressures characterized Southern Asia, not

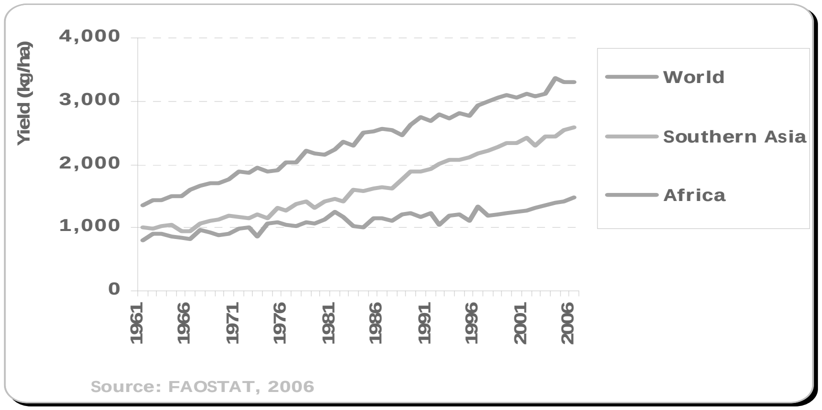
Africa. But by 1988 India alone had managed to triple its production of cereals from 50 to 150 million metric tons through the combination of Green Revolution technologies (seeds, fertilizer, and irrigation) and pro-agricultural policies. In some parts of Asia, cereal yields doubled in the space of just a few years. In China, rapid agricultural growth from 1978 to 1984 led to a doubling of rural income and accounted for the largest single instance of poverty reduction in human history (Ravallion, Chen, and Sangraula 2007; Gulati and Fan 2008). Faster agricultural growth has also put countries on the path of a much broader transformation process: rising farm incomes raise demand for industrial goods, lowered food prices curb inflation, and induced nonfarm growth increases the demand for unskilled workers. Rising on-farm productivity also encourages broad entrepreneurial activities through diversification into new products, the growth of rural service sectors, the birth of agroprocessing industries, and the exploration of new export markets (World Bank 2008).

But achieving a fundamental and sustainable transformation of African agriculture requires a new vision, as well as renewed efforts of both national and international policymakers. This new vision must deal with the fundamental causes of low productivity and lack of competitiveness in African agriculture and, ultimately, the resilience and ability of African economies to respond to international price shocks and emerging threats such as climate change. Such a vision must address four objectives for Africa. First, it must use Africa's short-run supply potential to help address the continent's most immediate problem—food shortages and food price inflation. Second, it must directly address Africa's short- and medium-term development challenges: poverty, hunger, and malnutrition. Third, it must put Africa on an overall economic development and sustainable development path. And finally, this vision must be centered around a regionwide perspective to take advantage of scale economies and multicountry growth linkages from greater market integration and technology spillovers. Sustaining economic progress well into the future will require African countries to undergo the similar economic transformation and modernization witnessed on other continents.

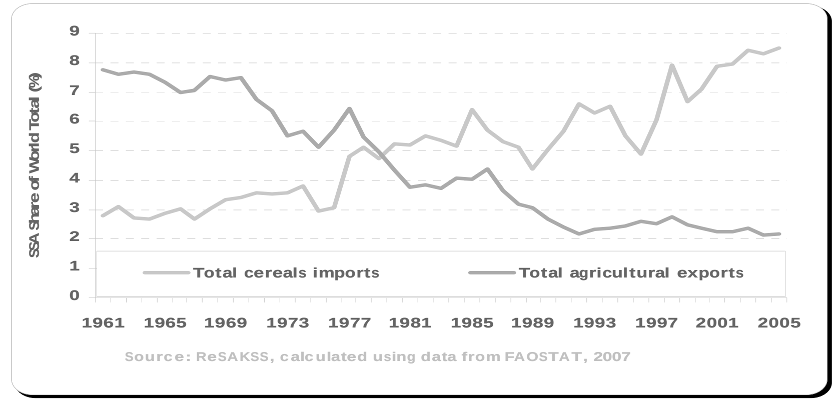
In this paper we propose that a staples-led growth strategy—a strategy centered on rapid growth in staples production in conjunction with improved regional economic integration—can deliver those outcomes with feasible policy actions (Section 2). We test this hypothesis using an economywide multimarket model (described in Section 3), as well as some simple simulations based on econometrically derived estimates of the linkages between agricultural growth, poverty, and public investment. The merit of this approach is that we can rigorously estimate the broader economic impacts that this strategy would have on African development (Section 4). With equal rigor we can also inform the question of what such a strategy might cost in terms of public investment, as well as the broader issue of what complementary policy actions would be required in Africa, especially in terms of improving market access (Section 5).

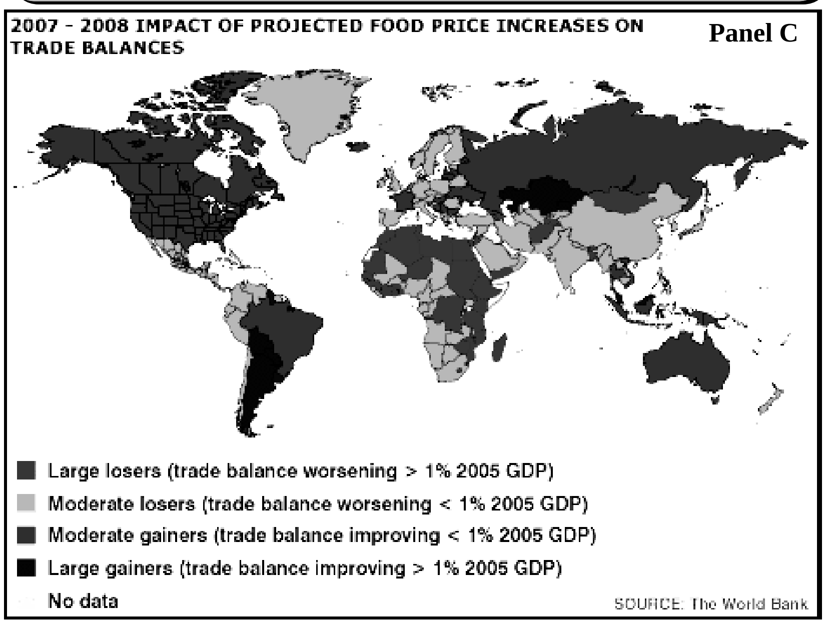
Box 1. Africa's vulnerability to rising food prices

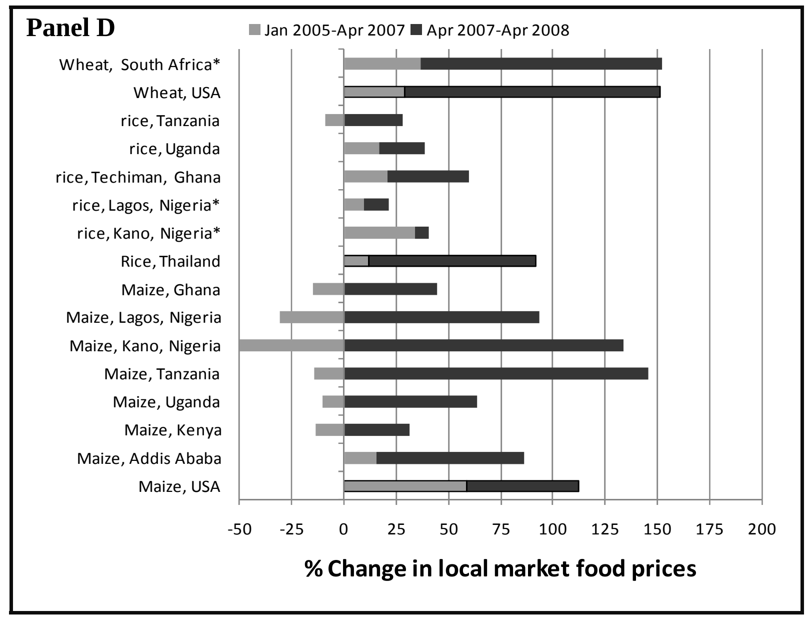
Panel A. Cereals yield, 1960–2006



Panel B. Rising dependency on cereal imports







2. DOUBLING AFRICAN FOOD PRODUCTION: A BROAD-BASED GROWTH STRATEGY

Secure access to a sufficient quantity of nutritious food is a fundamental human right, but recent rising food prices are increasingly threatening that right, especially in Africa. The immediate goal of a contemporary agricultural development strategy for Africa must therefore put the highest priority on the production of food, especially staples. But putting staples at the top of the agenda not only addresses short-term problems; it also promotes broader economic progress and poverty reduction.

Targeting staples is pro-poor in other important dimensions as well. African staples are largely grown by Africa's smallholders, who make up 70 percent of the continent's farmers (Johnson, Hazell, and Gulati 2003), so growth in staples production will typically be highly pro-poor. A wide range of research has also demonstrated the importance of food staples—in both the crops and livestock sectors—in driving growth and contributing to a dynamic structural transformation of rural economies (Byerlee, Diao, and Jackson 2005; Bezemer and Headey 2008; Hazell and Diao 2005; World Bank 2008). Acceleration in staples production has also been found to produce second- and third-round effects on the broader economy by reducing food prices for urban consumers, curbing overall inflation, and releasing scarce foreign exchange for the importation of goods that are typically unsuited to production within Africa (Diao et al. 2007). And in the longer run the productivity growth in African staples agriculture will facilitate a more fundamental transformation in the broader economy through new opportunities for industry (e.g., agroprocessing), growth opportunities for rural nonfarm activities (Haggblade, Hazell, and Reardon 2007), and increased regional and international trade, as well as new employment options through expanded migration.

A staples-led growth strategy also makes use of Africa's comparative advantage. Africa's natural agricultural resource base has considerable potential for rapid productivity growth in staples. A comprehensive global assessment of the world's agricultural ecology by Fischer et al. (2002) shows that Africa has 420 million hectares of land with high cultivation potential (moderate or slight constraints for agricultural production), yet in 2003 only 180 million hectares (of all land types) were under cultivation. High-yielding varieties of seed can work in Africa, and a science-based revolution of African agriculture is feasible in a technical sense (Johnson, Hazell, and Gulati 2003; Evenson 2003; Evenson and Rosegrant 2003; Evenson and Gollin 2005). Fertilizer consumption, although exceptionally low in Africa, can quickly be scaled up under the right conditions. In Kenya, Malawi, and Uganda, for example, the implicit costs that smallholders face in obtaining fertilizers have been greatly reduced by multipartner efforts to tailor the fertilizer market to the needs of smallholders and small-scale agro-dealers (World Bank 2008, 153). In terms of irrigation, available data suggest that most of mainland Sub-Saharan Africa (excluding South Africa) uses less than 20 percent of its irrigation potential, meaning that Africa has considerable scope to reduce its dependency on volatile rainfall patterns (FAO 1997). Although expanding irrigation is desirable, the unique challenges to developing irrigation in Africa must be carefully weighed. Low and scattered population densities may require smaller irrigation schemes, but on the other hand larger irrigation schemes can take advantage of scale economies and thus result in a higher rate of return to investment (see Innocencio et al. 2007 for more details on the returns and challenges to irrigation investments in Africa). And whilst the modernization of African agriculture still requires careful environmental management, that modernization can also help protect Africa's natural resources through restoring soil nutrients via increased fertilizer usage.

The broader economic environment for African agriculture is also improving. African countries have experienced rapid improvements in general governance scores and in macroeconomic stability.[1] Moreover, in 2002 African governments signed onto the Comprehensive Africa Agriculture Development Programme (CAADP) of the African Union and New Partnership for Africa's Development (NEPAD),

[1] Twenty-seven of Africa's 40 countries registered improvements in widely used governance scores from 1996 to 2006 (WDI 2008).

which shows that accelerating agricultural development on the continent has become a common goal for most African countries. In 2003, the heads of African countries endorsed the targets of 6 percent annual agricultural growth and 10 percent budget allocation to agriculture under the CAADP framework. These multicountry development strategies also emphasize the growing recognition that greater cross-country cooperation and economic integration will allow African countries to make better use of scale economies, expand regional markets, and expand opportunities for trade through differences in comparative advantage. In the set of countries we study, serious efforts to implement CAADP have already been set in motion.

In summary, the rationale for targeting the growth of staples production in Africa is sound. It is pro-poor, pro-growth, and consistent with Africa's comparative advantage, but it is also a strategy made additionally feasible by the recent commitments of African governments toward scaling up their investments in agriculture via a stronger multicountry regional perspective. That said, policymakers still need hard numbers on the impacts that this strategy could be expected to have on Africa's response to the current food crisis, as well as its longer-run economic development. In the next section we outline a methodology capable of providing such numbers.

3. METHODOLOGY

To assess the likely economywide impact of a staples-led growth strategy in Africa we develop an economywide multimarket (EMM) model that explicitly measures the potential effects of rapid increases in productivity (essentially doubling production) on the supply, demand, and prices of food staples between 2009 and 2013. The modeling exercise is augmented with additional analysis to determine the potential impact of such a strategy on poverty and the required level of public-sector investments and complementary policy actions. In this section, we briefly discuss the key features of the model and simulation exercises.

The Economywide Multimarket Model

The EMM model is based on neoclassical microeconomic theory and falls short of the more standard general equilibrium model. IFPRI has used the EMM model for a number of country- and regional-level studies that assess options for agricultural growth and agricultural growth's economywide impact on poverty in Africa (see, for example, Diao and Nin Pratt 2007; Omamo et al. 2007). In general, a multimarket model is a partial equilibrium model that typically focuses on a single sector in an economy, such as agriculture. Although the EMM model developed for this study focuses primarily on agriculture, other important economic activities (i.e., industry and services) are also included as two aggregated sectors. Thus, the model partially captures general equilibrium linkages within the economy and across key sectors within agriculture. The agriculture sector is disaggregated into a number of key economic activities, either as individual subsectors or as a group of commodities.

The EMM model includes 17 Sub-Saharan African countries (Angola, Cameroon, Ethiopia, Ghana, Kenya, Liberia, Madagascar, Malawi, Mali, Mozambique, Nigeria, Rwanda, Senegal, Sierra Leone, Tanzania, Uganda, and Zambia). These countries have explicitly acknowledged the importance of agriculture in their economies by agreeing to allocate more public resources and undertake policy reforms to achieve higher growth rates in yields as modeled here. Moreover, the list includes some of the continent's most populous and most important economies, such as Nigeria and Ethiopia. Although productivity growth is assumed to take place in the staples sectors of these 17 economies only, its effects are measured on all other countries in the region. Therefore, the entire Sub-Saharan African continent (excluding South Africa) is included in the study. There are 15 agricultural commodities (crops and livestock) and two aggregate nonagricultural activities included in the model. The agricultural commodities are maize, rice, sorghum, millet, wheat, barley, other cereals, cassava, yams, other roots, oil crops, pulses, other crops, poultry, and other livestock, and the nonagricultural sectors are industry and services.

A more detailed overview of the model structure can be found in Appendix A, which also discusses the limitations of the EMM model as they relate to the model's treatment of factor inputs and distributional impacts. Of additional concern is that an EMM simulation is generally more sensitive than a general equilibrium model to the assumptions embedded in the model, especially the choice of both demand and supply elasticities. Appendix A therefore also provides some sensitivity tests based on variations of the model's core assumptions. The main finding is that the only variation capable of yielding very different results is the switch from positive to negative income elasticities for commodities such as poultry and rice, although in this case we believe our baseline assumptions are much more realistic than the alternative. Nevertheless, these and other caveats cannot be dismissed altogether. Ultimately, the adoption of the EMM model still needs to be couched in terms of the inevitable tradeoff between existing data constraints and the desire to obtain rigorous answers to the types of questions that we wish to address.

Simulation Scenarios

In this study we conduct two simulations. In the first we consider only broader economic effects of a staples-led acceleration in productivity, together with modest land expansion. The total increase in yield by crop and country is calculated based on estimated yield potential and the gap between current actual yields and maximum yields achieved elsewhere in the region (in most cases in South Africa).[2] In effect, we assume that Africa's staples production systems can catch up to their own regional productivity frontiers (or meta-frontiers) rather than the more ambitious assumption that they catch up to a global productivity frontier. This regional meta-frontier can be thought of as representing the maximum attainable productivity levels or yield for each individual staple crop in the region. The average annual growth rate of staples production is calculated such that the countries can converge to the meta-frontier over the next five years (2009–2013), assuming a greater number of farmers will be able to adopt more modern inputs (e.g., seeds and fertilizer) and best farming practices to raise yields. The land expansion is based on the historical trend of recent years and varies across countries and crops. With accelerated growth in productivity or yields among the 17 African countries, together with modest increases in crop areas, Africa-wide grain production is expected to be doubled and production of root crops, other staple crops, and livestock will significantly increase by 40 to 70 percent in the next five years. Although the population growth rate implicitly affects the rate of land expansion, it is not included in the model, except insofar as we report per capita income and consumption. It is also important to point out that because supply responses and price changes are endogenous, the actual growth rates in both yield and area expansion are themselves endogenous results of the model, and therefore different from the exogenous growth rates assumed in the yield and area functions.

In the second scenario we simulate the combination of two different scenarios imposed on the model. In addition to the staples productivity growth scenario, we try to capture the effect of a shift to more integrated regional markets. Specifically, we assume that all tariff or nontariff barriers to trade are removed through, for example, greatly improved transportation networks and deregulated trade and transport policies, which results in liberalized markets and trade between countries (see Section 4 for more discussion). This implies that supply now meets demand at the continental level and the net exports or imports as trade with the rest of the world are defined at the regional level rather than at the country level. "Improved market access" is also captured within the domestic market of each country by imposing a reduction in the domestic marketing margins between producer and consumer prices. The margin or gap between producer and consumer prices is exogenously lowered gradually over the five-year period in our study, from 40 to around 20 percent by 2013 with a 15 percent annual reduction rate. Such "domestic market improvement" also implies that there will be differences between the degree to which consumer and producer prices fall in response to increased staples supply, which we will discuss later.

[2] While it is hardly fair to compare much of Africa's smallholder agriculture with the performance of South Africa's larger commercial agricultural sector, the calculated yield gaps turn out to be quite reasonable. Maximum attainable grain yields for rain-fed maize, rice, and wheat for Africa were estimated by Fischer et al. (2002) to have the potential to increase by threefold to sixfold in the short run if farmers were able to move from low to intermediate input use, and from low to high input use, respectively. The increase in our sample is much more conservative, barely a twofold increase. This is more reasonable considering the current poor state of infrastructure, modern input use, research, and extension systems in most countries in the region.

4. ASSESSING THE IMPACTS OF STAPLES-LED GROWTH IN AFRICA

To assess the broad economic welfare impacts of a staples-led growth strategy in Africa, we primarily focus attention on measuring its effects on food security overall, possible changes in food prices, farmer revenues, overall agriculture growth, and poverty reduction. Although we discuss the results mostly at the Africa-wide level, model results are actually obtained at the country level.

Impact on Region's Food Security

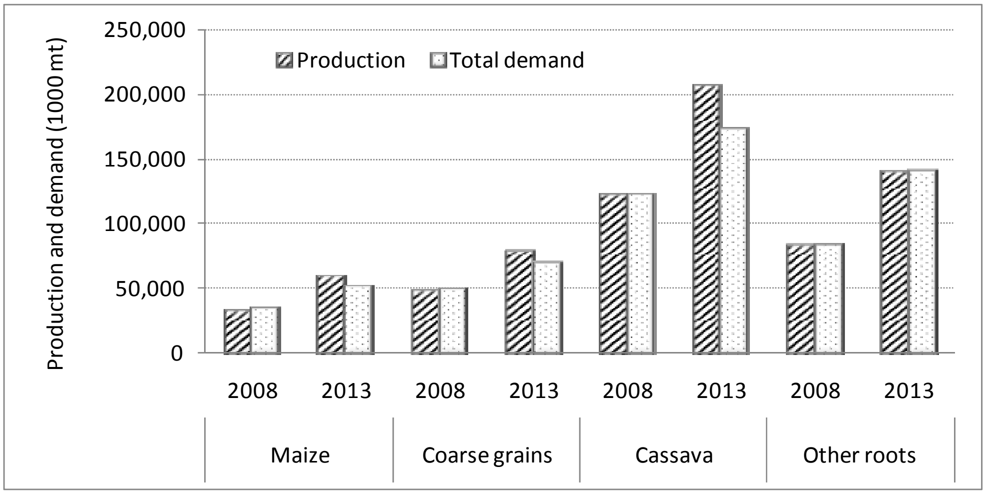
Figure 1 presents a projection of the change in imports as a percentage of total demand for rice, wheat, and poultry over the period 2008 to 2013. Many African countries depend greatly on imports to meet domestic demand for these three commodities. For example, 60 percent of rice and 90 percent of poultry meat consumed by Ghanaians in domestic markets has been imported from Thailand, China, Vietnam, and Brazil. Therefore, growth in per capita incomes and urbanization is expected to continue to put a huge pressure on import bills in many African countries. Although doubling domestic rice and wheat production may partially allow some degree of import substitutions for these commodities, the model results suggest that Africa as a whole will not be able to become self-sufficient in these two cereals. African cereal imports are therefore not expected to decline much in absolute terms. However, imports as a percentage of domestic demand could fall. For example, the share of imports in Africa's domestic demand for rice declines to 12 percent by 2013 from 32 percent currently. Hence a staples-led growth strategy will certainly relieve much of the pressure currently being placed on Africa's cereal import bill. This is even considering the high growth rates in consumption over time as incomes rise. By 2013, Africa as a whole will be consuming 50 percent more rice and wheat and 60 percent more poultry as incomes rise for the majority of the rural and urban population due to the initial acceleration in agricultural growth.

Figure 1. Reduction in Africa's dependence on imports, 2008–2013

Source: The African EMM model simulation results.

Among local staples, maize, sorghum, millet, cassava, yam, and other root crops are the most important starchy foods in the diets of most Africans, particularly in rural areas. Figure 2 presents the balance between supply and demand of these major staple crops in 2008 and 2013. The rapid growth in these staple crops, which are mainly grown by small (and often subsistent) farmers, will allow many poor rural households to switch from being net buyers to net sellers of these commodities, thus significantly improving food security in rural Africa. Moreover, increased supply will lower food prices in domestic markets, enabling urban consumers to consume more without increasing their total expenditure on food.

Figure 2. Improvements in Africa's food security, 2008–2013



Source: The African EMM model simulation results.

Whilst food security is expected to improve significantly, growth in staples production can also serve as an engine for income growth for the majority of smallholder African farmers. To realize that objective, farmers need to have adequate access to markets. It is therefore necessary to examine the broad market opportunities for food staples in Africa, an issue that is beyond the immediate food security objective. Although a majority of households (particularly in rural areas) consume much more of the traditional staple crops (maize, sorghum, millet, and root crops) than rice and wheat, the income elasticity of consumer demand for those staples is low; that is, many consumers prefer to spend more of their rising incomes on rice and wheat rather than on the traditional staples. Because of this, the growth in food demand for traditional staples will lag behind the growth in supply of these commodities following any rapid increase in their yields. Taking into account both population and income growth to estimate future demand, the model projects only a 20 to 25 percent increase in food consumption of the traditional staples over the next five years compared with a 50 percent increase for rice and wheat.

Market opportunities for traditional staples also exist for other than human consumption. Maize and other coarse grains, as well as some root crops such as cassava, are also consumed by livestock as feed. Currently, feed demand for such crops is extremely low in Africa as traditional technology dominates livestock production in the region. Under improved livestock production technologies, coupled with a growing demand for livestock products (particularly in urban areas and as incomes rise), the demand for feed will quickly rise. The model considers this potential by explicitly considering a significant increase in feed demand when livestock production grows rapidly, particularly poultry. It is reasonable to assume that the demand for poultry will grow rapidly in Africa, especially as urbanization proceeds and per capita incomes rise.[3] Presently, any demand growth is being met mostly through increased imports. If domestic poultry production grows rapidly to meet this demand, the model projects that feed demand for maize, for example, could easily grow by as much as 180 percent by 2013. Meanwhile, the feed-to-food ratio for maize will rise to 5 percent from the current low level of 2 percent. Even with such rapid growth, the model may be underestimating the growth in feed demand given that little modern technology is being used by most farmers for poultry and livestock production in Africa, and even if modern technologies are widely adopted, the potential for import substitution will remain high for poultry.

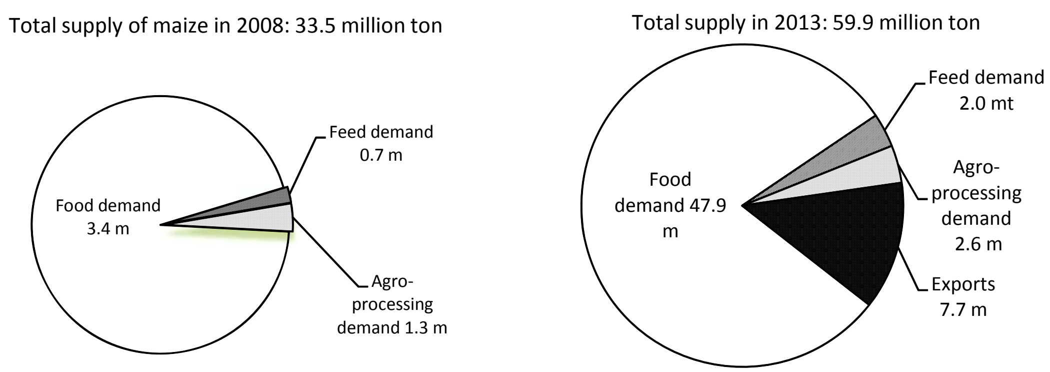
[3] Calculated from FAO data, per capita meat consumption grew by 8 percent in China annually between 1978 and 1994 when the country started its rapid economic growth and urbanization.

Experience from Thailand indicates how huge the market opportunities for maize could be if the poultry sector is developed. Thailand has become a very large poultry exporter since the late 1980s. The rapid growth in exports has created a big market for maize consumption in the country. Before that, feed demand accounted for only a small portion of maize production (3–7 percent), as in Africa today. With the development of the poultry industry, feed demand in Thailand now accounts for 70 to 80 percent of maize production (a tenfold increase over two decades). It is therefore reasonable to believe that development of the poultry sector in Africa offers an opportunity for maize production to grow, making it not only an important staple commodity for human consumption but an important cash crop for many of the continent's smallholder farmers.

Staple crops also serve as important inputs in agroprocessing industries. The potential market opportunities in this sector are especially large if growth rates are accelerated in both agriculture and nonagriculture. The model also assumes a doubling of these types of input demand for staples over the next five years. This is a very conservative assumption given the small base from which these sectors will expand.

By taking into account all these important sources of potential demand for staples—food, feed, and agroprocessing industries—75 percent of the increased supply in staples can be met by domestic and regional demand, while 25 percent will need to be exported outside the continent (see the case of maize in Figure 3).

Figure 3. Broad market opportunities for maize in Africa



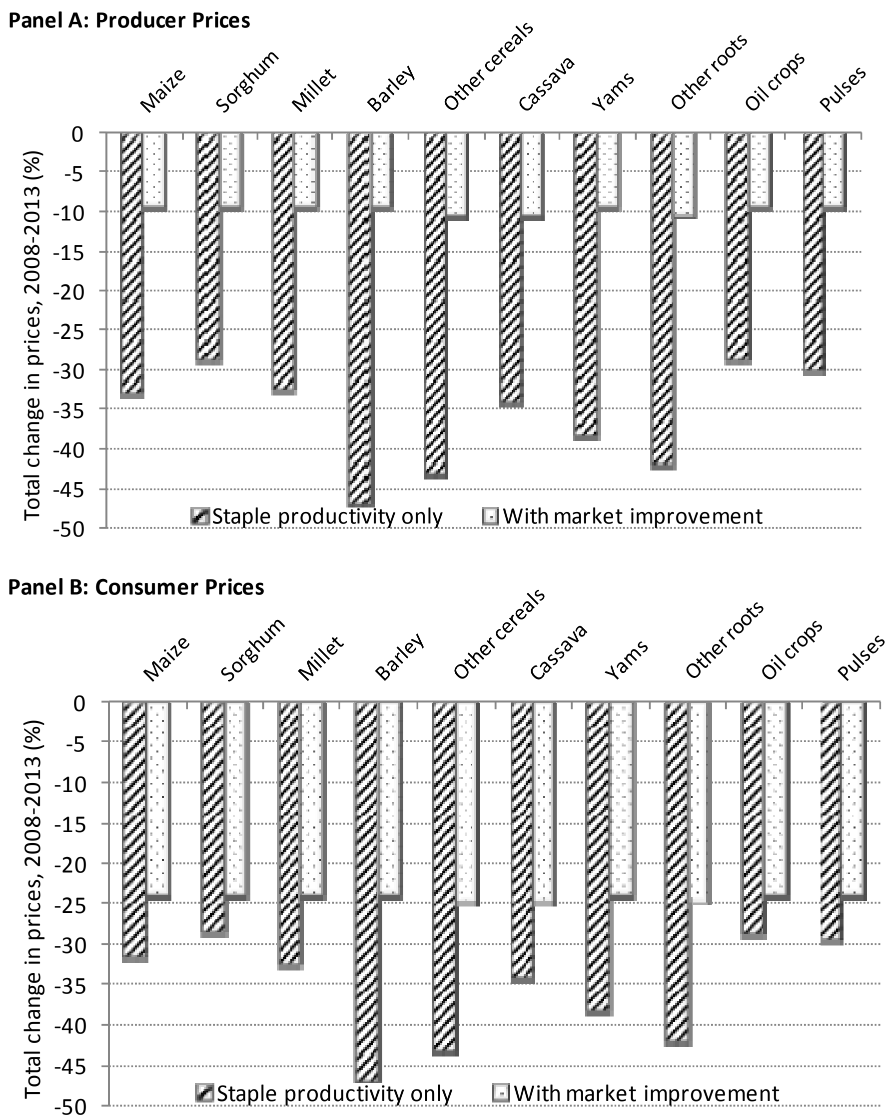
Source: The African EMM model simulation results.

The good news is that promising export opportunities in global markets do exist for many staple crops. We take cassava as an example, and again refer to Thailand's experience. Although more than 60 percent of world cassava is produced by African farmers, and although Thailand's share is less than 10 percent, it exports 80 percent of its production, which accounts for 70 to 80 percent of world cassava trade, mostly for the feed and starch industry. Cassava chips and flours are broadly used for both feed and agroprocessing sectors in many countries. World cassava exports currently amount to 22 million metric tons. In contrast, Africa produces about 100 million metric tons in total, and then mainly for domestic food consumption. It is therefore reasonable to expect that with the adoption of high-yield varieties, cost-effective processing technologies, and improved market access conditions, African cassava could successfully be exported to the rest of the world. Under such a scenario, large producers such as Nigeria could become dominant cassava exporters.

What Will Happen to Food Prices?

Although increased food production would appear to benefit both farmers and consumers, that is not necessarily always the case. Indeed, increased supply can cause rapid declines in food prices, which may even result in net revenue losses for farmers, thereby discouraging production. However, when production growth is driven by productivity and the necessary policies to stabilize prices are in place so that market speculation is minimal, farmers should in general benefit from productivity growth even with lowered prices. A more integrated African market also helps stabilize prices, as surpluses from one country can find demand in other countries. For this reason we distinguish between a scenario with productivity increases only under current market conditions and one with improved and more integrated market access conditions. For the latter, we consider two specific assumptions: (1) pervasive reductions in trade barriers across Africa such that agricultural goods can move freely between countries; and (2) lowering price margins in domestic markets such that the gap between producer and consumer prices falls from around 40 percent of producer prices to around 20 percent. As shown in Figure 4, the effects of improving market access are that (a) producer prices fall by a mere 10 percent rather than the 35 to 40 percent if market conditions stayed the same (Panel A); and (b) consumer prices fall more than producer prices, by around 25 percent (Panel B).

Figure 4. Changes in producer and consumer prices for selected staples in the two scenarios

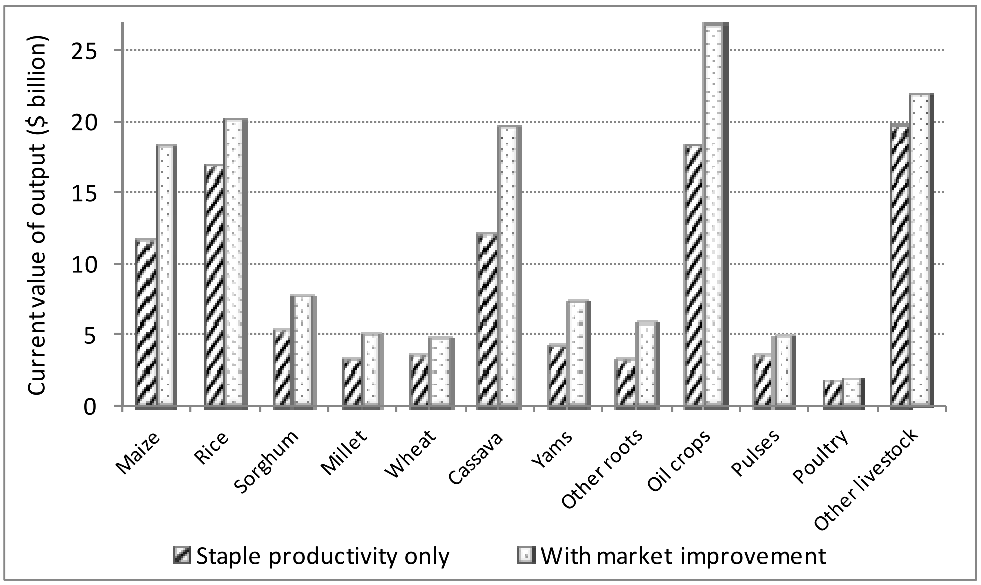


Source: The African EMM model simulation results.

What Will Happen to Farmer Revenue?

Under the improved market access scenario, the modest decline in producer prices means that farmers will be able to have strong incentives to maintain high levels of production, given that farmers' revenue is determined by both the amount they produce and the prices they receive.[4] Not surprisingly then, a more integrated African market for staples together with producivity increases significantly raises farm revenues in comparison with productivity increases only. Figure 5 presents total farmer revenue from each staple commodity. The difference between the two scenarios is the combination of a smaller decline of producer prices and the faster growth in supply. The faster growth in supply with better integrated markets occurs as a result of stronger incentives for farmers to maintain high production growth rates as they face a higher price regime with greater market opportunities. The difference in farmer revenue coming from major staple products between the two scenarios is about $40 billion, or a 40 percent increase in five years. Increases in cassava and maize revenue from a more integrated regional model is especially significant, $6.6 and $7.5 billion in total in the five years, indicating the vital contribution of improved market conditions (e.g., through better market integration) for these two important staple commodities.

Figure 5. Increases in farm revenues for selected staples in the two scenarios over 2009–2013



Source: The African EMM model simulation results.

What Will Happen to Overall Agricultural Growth and Economic Growth?

Staple crops and livestock are the most important agricultural activities across most African countries. As shown in Figure 6, when staples grow rapidly, total agricultural growth reaches more than 10 percent annually for most countries. The growth rate for the 17 countries as a group reaches 12.5 percent, and it is 11.3 percent for all of Sub-Saharan Africa. Such growth is achieved partly due to a more integrated Africa-wide market. Without greater market integration, the agricultural growth rate for Africa as a whole would be lower, at about 9.5 percent. In other words, improved market integration allows African agriculture to grow by two percentage points more as productivity rises, compared with the scenario when productivity rises alone under current market conditions. Among individual countries, especially for those

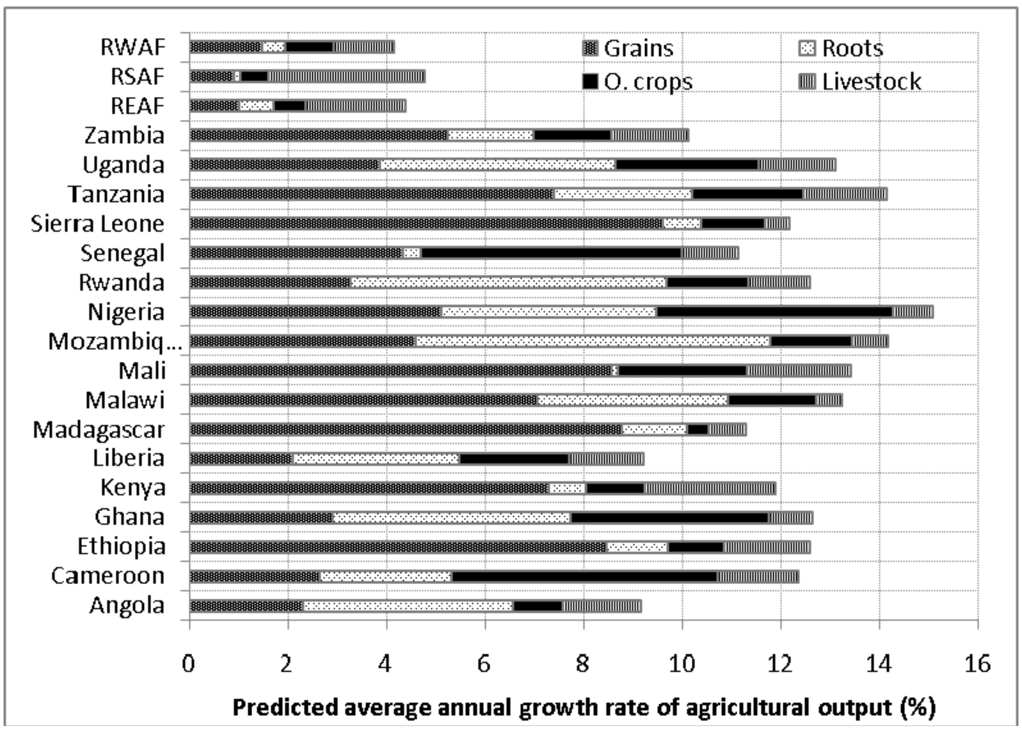
[4] As the EMM model does not explicitly model the use of inputs and hence the production costs, the farmers' revenue reported here does not equal the net profit going to farmers' family labor and land.

with large surpluses in domestic markets, the benefit in growth from regional market integration is even greater. Nigeria, for example, would enjoy a 15 percent annual agricultural growth rate if it were able to export its commodity surpluses to neighboring countries. In contrast, it would grow only at 12 percent without such export opportunities.

Figure 6 also displays the contributions of accelerated productivity growth together with more integrated regional markets within each agricultural subsector to overall agricultural growth. In general, the grain sector contributes the most to overall agricultural growth. However, for some countries, growth in root crops contributes the most. Growth in livestock is also important among some countries, particularly Mali, Kenya, and Ethiopia. The diversity in growth rates within and between different agricultural sectors and across African countries further validates the urgent need for promoting a more integrated African market as it will generate broader benefits from growth through realization of comparative advantage.

Because of the importance of agriculture in the economy for most African countries, accelerating staples growth stimulates the overall economic growth. Annual growth rate in gross domestic product (GDP) for the 17 countries as a whole rises to 7.1 percent, and will further increase to 7.7 percent with more integrated regional markets. Such economywide growth is an outcome of agricultural growth as a direct contribution, but it is also an outcome of the linkage effects between the agricultural sector and nonagricultural sectors and between increased rural income and hence demand and production growth induced by such demand.

Figure 6. Agricultural annual growth and subsector contribution, 2009–2013



Source: The African EMM model simulation results.

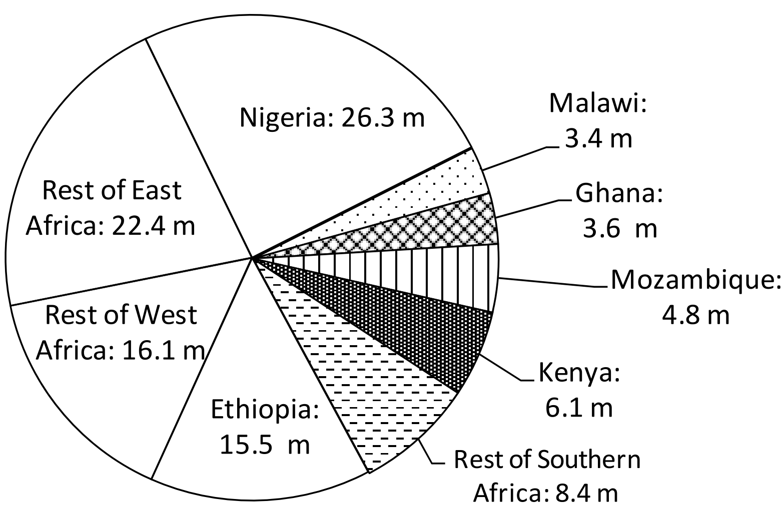
Notes: RWAF refers to other West African countries, REAF refers to other East African countries, and RSAF refers to other Southern African countries, where “other” refers to countries not shown and therefore experiencing the food productivity increases simulated in the model.

What Will Happen to Poverty Reduction?

Many studies in literature have shown that agricultural growth in Africa, particularly growth led by staple crops and livestock, is more pro-poor than growth led by the nonagricultural sector (Diao et al. 2007; Christiaensen, Demery, and Kühl 2006; also see Bezemer and Headey 2008 for a review). There are several good reasons for this. First, growth in staples production is often broad-based as staples are typically grown by a majority of smallholder farmers. Poor farmers directly benefit from increasing their own food consumption, their land and labor productivity, and ultimately, their incomes. Second, the growth in staples production further benefits the poor through its effect on food prices. The poor spend most of their income on food, and lower food prices allow them to consume more without increasing spending. Finally, staples growth also has strong multiplier effects on other sectors through production and consumption linkages, which stimulate additional growth in nonstaples agricultural as well as in nonagricultural sectors, such as manufacturing, construction, and various services (Delgado, Hopkins, and Kelly 1998).

Taking into account these direct and indirect effects of staples growth, Figure 7 predicts the potential poverty reduction effect of the staples-led growth strategy considered here. Poverty is measured as the headcount of poor people in Africa earning less than $1 per day for the most recent year for which data are available. The link between the projected agricultural growth rates from the modeling results with poverty reduction is calculated using the so called growth–to–poverty reduction elasticity. This elasticity has been estimated or measured in the economics literature for a number of different countries (see, for example, Fan et al. 2008 for a review of different elasticity measurements). We adopt these elasticities in the current study.

Figure 7. Staples-led growth with market integration lifts 107 million Africans out of poverty by 2013



Source: The African EMM model simulation results.
Note: "Rest of" refers to countries experiencing food productivity increases simulated in the model as well as to other countries in each subregion of Africa.

In total, we find that accelerated staples growth, together with more integrated African markets, has the potential to lift 107 million Africans out of poverty by 2013 (Figure 7). If market integration is not achieved, the degree of poverty reduction will be less, at around 98 million. Therefore, market integration alone contributes to the lifting of almost 10 million Africans out of poverty. Unsurprisingly, given their exceptionally large size or relatively low incomes, the greatest reductions in poverty will take place in Nigeria (26.3 million), Ethiopia (15.5 million), Kenya (6.1 million), Ghana (3.6 million), Mozambique (4.8 million), and Malawi (3.4 million). However, other countries are also projected to experience poverty reductions that are significant relative to their populations (Figure 7). Moreover, the poverty rate is estimated to diminish by 18.7 percentage points Africa-wide, from 50.2 percent in 2008 to 31.5 percent in 2013.

Summary of the Modeling Results

The EMM model analysis for African economies has successfully demonstrated that accelerating staples productivity—in conjunction with substantial improvements in regional integration—has the potential to generate a range of positive outcomes that address both Africa's short-run food security issues and the region's longer-run development constraints. Food prices would decline by around 10 percent for producers and by 20 to 30 percent for consumers. Meanwhile, food availability increases rapidly as many countries move from food deficits to food surpluses. This in turn opens up new avenues for net food demand for staples from increased regional and international trade, and in the process, creates additional investment opportunities for the agroprocessing and livestock private-sector industries. Finally, the strategy turns out to be inherently pro-poor, yielding increased revenues for farmers, most of whom are smallholders, and significant food price declines for both rural and urban poor consumers. Accompanied by greater market integration, the rapid acceleration of productivity in the staples sector has the potential to lift more than 100 million Africans out of poverty.

5. MOVING FROM STRATEGY TO ACTION

As shown in the preceding section the estimated benefits of a staples-led growth strategy in Africa are large, especially when accompanied by increased market access through improved infrastructure and regional trade integration. However, to realize such benefits the countries of Africa need to take some signfiicant policy actions. In this section we discuss those appropriate policy actions partly based on existing literature and partly our own analysis.

Accelerating Public Investment and Strengthening the Public Provision of Agricultural Inputs

The determinants of accelerations in agricultural production, which have occurred elsewhere in the developing world, especially Asia, have been amply documented (Johnson, Hazell, and Gulati 2003; Evenson and Gollin 2003; Rosegrant and Hazell 2000; World Bank 2008). The foundation of Asia's Green Revolution, as well as agricultural modernization in Latin America, North Africa, and the Middle East, was the combination of increased access to a package of modern agricultural technologies—high-yielding varieties of seed, chemical fertilizers and pesticides, and irrigation—together with broader improvements in infrastructure, particularly transportation and rural electrification.

History shows that the initial impetus for modernizing smallholder agriculture needs to come from the public sector, which provides investments in public goods, such as infrastructure and agricultural R&D in which the private sector will typically struggle for active involvement, especially at early stages of development. Moreover, given that many African countries are small, such investment needs significant regional collaboration. Yet the slowdown in foreign aid to agriculture (Box 2, Panel A) has only very recently started to reverse, and public agricultural R&D expenditures in Africa have generally been very low—mostly declining in the 1980s and 1990s (Fan 2008). In recent years, however, African countries have revitalized their commitment to agriculture under CAADP. One component of CAADP was a renewed effort to increase agriculture expenditure to at least 10 percent of total government expenditure. As of 2005, very few countries had achieved that target (Box 2, Panel B).

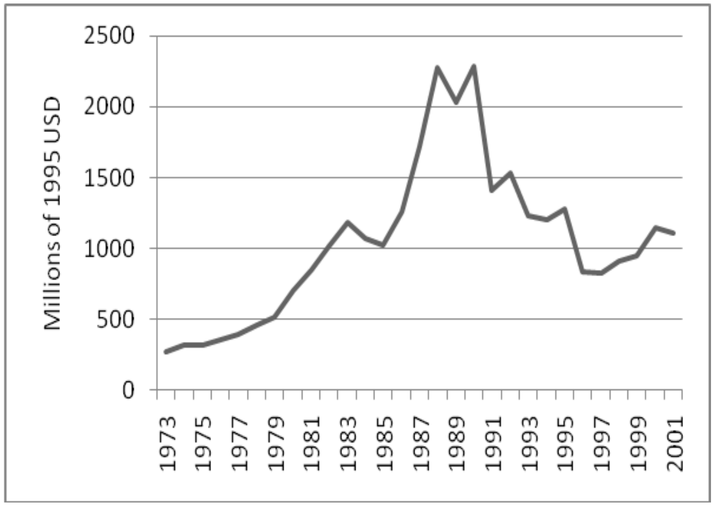
To quantify the specific amount of public spending in agriculture needed for a staples-led growth strategy, we use elasticities between agricultural growth and agriculture expenditure, and the growth rate obtained from the EMM model in Section 4.[5] That shows that the staples-led growth strategy requires total public spending of US$37.6 billion from 2009 to 2013, or US$7.5 billion[6] per annum, to achieve the required productivity growth in major food crops. If current spending patterns (US$16 billion from 2009 to 2013) were to continue, African countries would fall far short of the target. However, if the 17 African countries analyzed in this study were to achieve their CAADP spending targets—that is, devoting at least 10 percent of their government spending to agriculture—in the next five years, then they would achieve more than 80 percent of the public spending required for the staples-led growth strategy (see Box 1, Panel C, in details).

Africa therefore urgently needs to follow in the footsteps of rapid-response countries like China and India, where public agricultural expenditure has been increased by as much as 30 percent in recent years. Such public expenditures are needed on the essential combination of modern inputs, along with additional expenditures on enabling investments in infrastructure, especially. Such investments also need to take place quickly. As Figure 8 shows, Africa is lagging behind in the use of modern agricultural inputs, such as irrigation, modern staple varieties, and fertilizer.

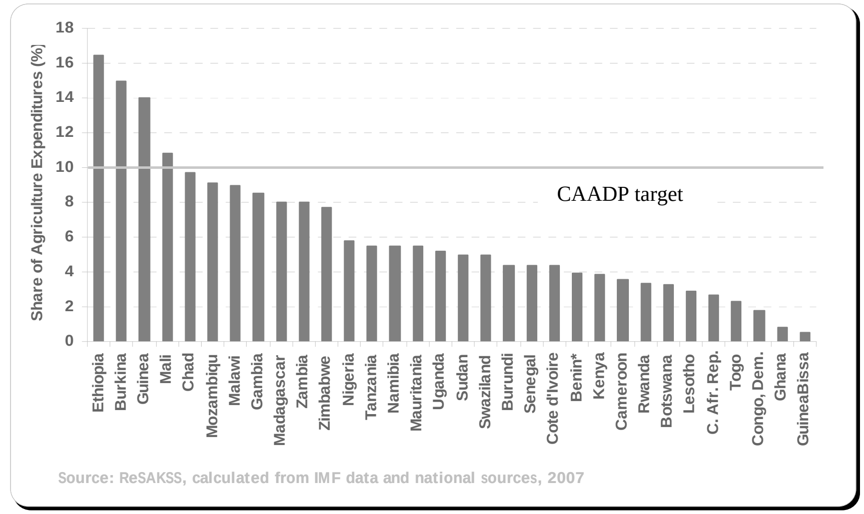
[5] For more details, refer to Fan et al. (2008).
[6] Measured in 2008 constant U.S. dollars.

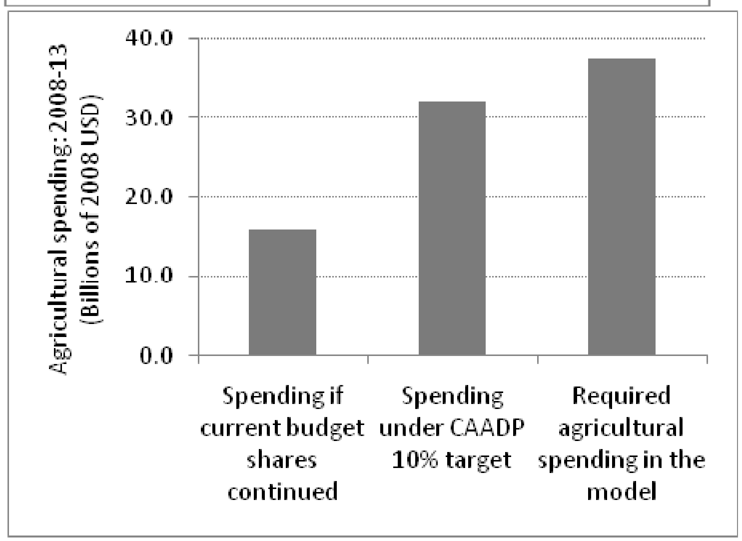
Box 2. Agricultural investment in Africa: Historical trends and projected requirements

Panel A. Foreign aid to African agriculture, 1973–2001



Panel B. African governments' agricultural expenditures (% of total expenditure), 2004





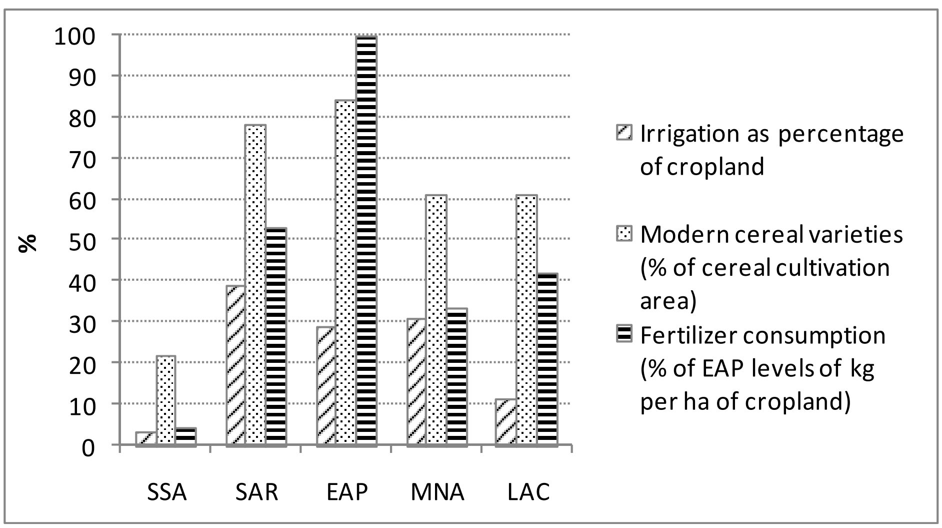
Panel C

Historically, investment in African agriculture has been very low. Foreign aid to African agriculture declined by about two-thirds during the 1990s (Panel A) before picking up in more recent years. Equally encouraging, a number of African countries agreed under CAADP to increase their own agricultural spending to 10 percent of total public spending. As of 2007, however, only a few countries had reached that target (Panel B). If such spending patterns continue, public agricultural expenditure in Africa—totaling $16 billion—will not be sufficient for achieving the accelerated staples growth, which is estimated to require $37.6 billion (Panel C). The good news is achieving the CAADP 10 percent targets would provide more than 80 percent of the required expenditure ($32.2 billion), and the remaining investments could feasibly be financed from donors, foreign direct investment, NGOs, and other sources.

Regarding the investments, the most controversial issues include the role of procurement programs and the use of subsidies in delivering agricultural inputs. Small farmers—who are especially prevalent in African agriculture—need access to credit on the input side as well as procurement programs on the output side, which can support prices for agricultural products that reflect long-term international market prices (von Braun et al. 2008). Some researchers and policymakers have also been highly critical of fertilizer subsidies and instead favor fertilizer supply responses (Gregory and Bumb 2006). The effectiveness of fertilizer subsidies is not a black-or-white issue, however. Although such subsidies played a large role in the early years of Asia's Green Revolution, those programs have since become very costly and increasingly counterproductive.

Nevertheless, in the current context—with fertilizer use exceptionally low in Africa and fertilizer prices extremely high due to high energy prices and transportation costs—the need for a rapid agricultural response cannot depend only on the supply response without significantly increasing the use of modern inputs to raise productivity. For this, input subsidies will be essential (von Braun et al. 2008). Subsidized programs for fertilizers need to proceed, but they need to build in sunset clauses and increasingly involve the private sector in order to facilitate a transition to market-based exits (von Braun et al. 2008). Moreover, sustainable increases in fertilizer use will indeed require fertilizer supply responses, partly through improving transport infrastructure (see following section).

Figure 8. Adoption of modern techniques in Sub-Saharan Africa and other developing regions



Source: World Bank 2008.
Notes: SSA: Sub-Saharan Africa, SAR: South Asia, EAP: East Asia Pacific, MNA: Middle East and North Africa, LAC: Latin America and Caribbean. No data are available on modern varieties adopted in Eastern Europe and Central Asia.

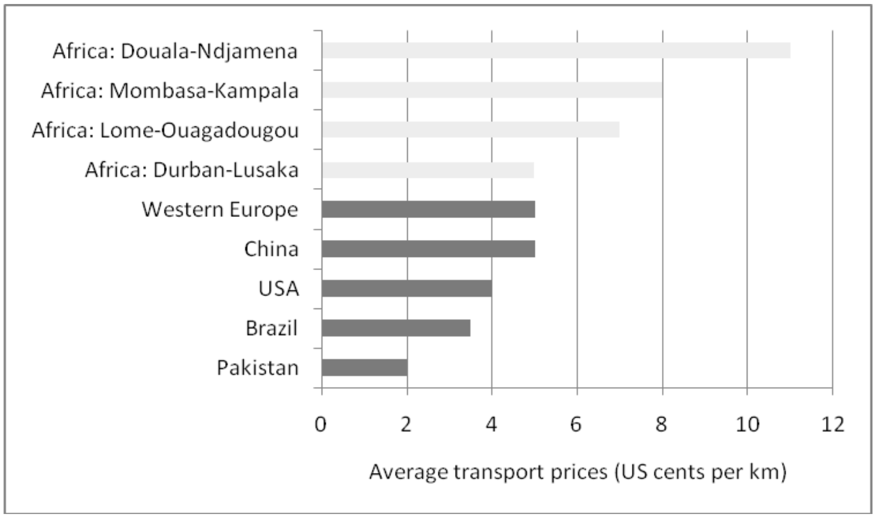
Improving Market Access

The economic returns to improving market access have been estimated in a variety of studies, and several have demonstrated that transport costs are especially high in Africa relative to other regions. Using cross-country analysis, Limao and Venables (2001), World Bank (2007), and Amjadi and Yeats (1995) find that the poor quality of infrastructure accounts for most of Africa's lagging performance in trade. Limao and Venables (2001) estimated that a 10 percent drop in transport costs would increase African trade by 25 percent, and that transport costs are highly sensitive to the quality of infrastructure, as measured by variables such as the density of the road and rail network. Several empirical studies use trucking surveys to reach similar conclusions. One study (Rizet and Hine 1993) estimated that prices of road transport in three Francophone African countries (Cameroon, Côte d'Ivoire, and Mali) were up to six times higher than in Pakistan, and about 40 percent higher than in France where labor rates are much higher.

According to another source, transport prices for most African landlocked countries range as high as 15 to 20 percent of import costs (MacKellar, Wörgötter, and Wörz 2002), which is three to four times higher than those in most developed countries.

Figure 9 summarizes some of these results for various transport corridors in Africa and other regions of the world. Transport prices are measured as U.S. cents per kilometer. With the exception of the Durban-Lusaka corridor, the remaining African corridors have much higher transport prices than other developed and developing regions. Indeed, Pakistan is the only other country at a stage of development comparable with Africa, and its transport costs are the lowest in the sample.

Figure 9. Average transport prices are generally high in Africa's trade corridors

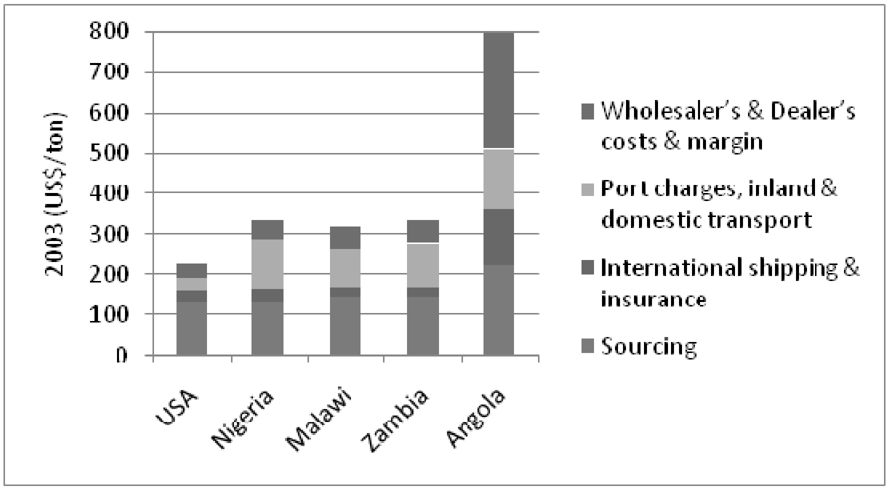


Sources: Various authors.

High transport costs are especially a binding constraint for agricultural trade because of the physical nature of agriculture's inputs and outputs, and because unlike manufacturing or mining, agricultural production does not take place in centralized locations. The modeling results from the previous section suggest that growth and trade accelerate much faster with increased regional integration in Africa. A similar study by Diao et al. (2003) also explores the implications of combining agricultural productivity growth with improvements in market access. Specifically, that study evaluates the real agricultural income gains from doubling agricultural productivity over a 12-year period, with and without productivity growth in the transport sector that reduces marketing costs. They find that real agricultural income gains are twice as high with total factor productivity (TFP) growth in transport as they are without such an improvement. Another study by Abdulai, Diao, and Johnson (2005) used partial and general equilibrium models to generate ex ante simulations of the size of regional spillovers in Africa. They conclude that sizable regional spillover benefits can be obtained by permitting greater cross-border transfers of goods, services, and labor, as well as increased adoption of improved technologies. Moreover, reducing trade barriers between African countries in agriculture and nonagriculture can significantly increase intraregional agricultural trade and raise economic growth rates. The simulations also demonstrate that improving transportation infrastructure generates the most encouraging results, increasing agricultural income by as much as 10 percent.

Transport costs are also an important constraint on the modernization of African agriculture. For example, high transportation costs increase the price of fertilizer for farmers. Gregory and Bumb (2006) find that transport costs make up about one-third of the farm gate price of urea fertilizer in most African countries (Figure 10). Those transports costs are three to four times higher than they are in the United States and explain almost the entire difference in fertilizer costs between most African countries and the United States.

Figure 10. Transport costs make up about one-third of fertilizer price in African countries, 2005



Source: Gregory and Bumb (2006).

We also note that improved market integration and increased technology flows, especially trade reform, tend to spread benefits unevenly both within and between countries (in the African context, see Nissanke and Thorbecke 2008; for a review of the Green Revolution's impacts on rural inequality, see Rosegrant and Hazell 2000). One of the lessons from the Green Revolution is the importance of proactive public policies in linking smallholders to both input and output markets, lest they be left behind in the modernization process. Likewise, trade liberalization needs to be done in conjunction with policies aimed at lowering domestic transaction costs so that the benefits of liberalization are shared between food producers and food consumers (Kherallah et al. 2002).

Increasing market access entails improvements in both large-scale transport corridors as well as small rural road networks to link farmers with the major transport routes.

Investing in Transport Corridors

Major transport corridors in Africa link major cities and markets across countries, and link inland areas with the coast to provide access to international markets. These corridors open up markets and facilitate trade, spread information and technology, and can certainly contribute to economic growth in the region. Moreover, they have the potential to reduce poverty and vulnerability. Because of variation in agricultural production—in terms of what is produced (cash crops or staples) and how productive agriculture is—African regions are pitted with food-surplus and food-deficit areas. Such areas can be linked by transport corridors and feeder roads to increase food security in the region. Seasonal price volatility is also an important factor constraining agricultural growth and adaptation of new technology by farmers. Prices can collapse during harvest season and double during lean seasons. Given different agro-ecological conditions between neighboring countries within a subregion of Africa, increasing intraregional trade can significantly lower seasonable price volatility.

The potential of transport corridors in Africa to induce these kinds of positive effects on economic development is highlighted by the fact that most such corridors typically run through or near Africa's most population-dense areas (World Bank 2008). The corridors therefore have the ability to directly or, through feeder roads, indirectly reach the majority of Africa's populations. Improving transport corridors requires policymakers to address a broad range of problems (see Box 3). In the past, large investments in improving road infrastructure were seen as the primary means of reducing transport prices. Although such improvements were essential to facilitate road transport and resulted in lower costs for the trucks carrying cargo on the corridors, no clear impact on transport prices has thus far been evident. A review of the World Bank's African corridor projects by the Bank's evaluation group found that most projects were limited in coverage to a single transport mode, a single government agency, and a single investment strategy (the development or rehabilitation of physical facilities), without putting in place the prerequisites for future operations such as regional agreements on corridor operations and the streamlining and harmonizing of regulation affecting transport.

Box 3. Addressing Africa's transport corridors

Despite their great potential, Africa's transport corridors need attention in the following areas:

Port Formalities
- Port formalities are inefficient and complicated due to lack of harmonization.
- Information and communications technology instrument use is inadequate. UNCTAD's Advance Cargo Information System is not used in the sub-region.
- Port clearing formalities take up to 10 days.

Border Formalities
- There is a multiplicity of customs documents and no harmonization of procedures.
- Little progress has been achieved on implementation of the Economic Community of West African States (ECOWAS) Inter-State Road Transit (ISRT) Convention.
- Protocols on the free movement of persons and goods have been inadequately implemented.

Control and Harassment
- Customs and police control and harassment are a major cause of delay in road corridors.
- Frequency of checkpoints is as high as one in every 10 kilometers in some corridors.
- Average cost per checkpoint is 20 minutes and 20,000 CFA francs.
- Undue payments account for 10 percent of transport costs.

Political Factors
- Implementation of regional agreements on transit transport is poor.
- Political instability hinders implementation of several ECOWAS agreements.
- Police and customs harassment increases in periods of political instability and insecurity.

Economic Factors
- Most aspects of customs control are motivated by lack of diverse sources of fiscal revenue.
- Import duties contribute a large share of fiscal revenue.

Transport Infrastructure
- Infrastructure network is thin.
- National railways are poorly interconnected.
- Inadequate maintenance and improper practices contribute to rapid deterioration.
- Vehicle fleets are often old and poorly maintained.
- Most vehicles do not meet standards for international transit transport.

Human Resource Capacity
- Low capacity is particularly acute in areas of customs clearing and vehicle operations.
- Some freight-forwarding agents are not adequately trained.
- Most vehicle operators are illiterate and inadequately trained.

The **following** new initiatives are under way to improve Africa's transport corridors:
- Implementation of ECOWAS's ISRT Convention
- Monitoring of improper practices in transit corridors
- Improvement of fluidity of road transit traffic
- HIV/AIDS control in transit transport corridor
- Infrastructure development

Sources: Kodgo Evlo (Université de Lomé); Independent Evaluation Group, the World Bank.

Recent partnerships between African governments and donors are learning from this experience by emphasizing the critical importance of reforming the broader transport environment in the corridors. The Improved Road Transport Governance Initiative—a partnership between the United States Agency for International Development and several local bodies—monitors harmful road practices on interstate trunk roads between Ouagadougou (Burkina Faso) and Tema (Ghana) and Bamako (Mali) and Lomé (Togo). That initiative has analyzed various nonphysical sources of higher transport costs (e.g., number of checkpoints, degree of regulation, prevalence of corruption) and also which countries and borders produce the most delays. Similar efforts are being devoted to achieving cross-country agreements, controlling HIV/AIDS, encouraging market development along the corridors, and upgrading and extending the corridors' physical infrastructure.

Investing in Rural Roads

Along the trade corridors in many countries, other principal intercity and rural feeder roads are often in much poorer condition than the main roads. Exceptions are found in countries such as Zambia, Tanzania, Ghana, and Nigeria, where there have been increased investments in improving both highways and intercity roads. However, even in those countries feeder roads linking to the rural areas remain in poor condition. Moreover, existing roads remain poorly maintained in the majority of countries, making the improvement of rural roads and highways equally important.

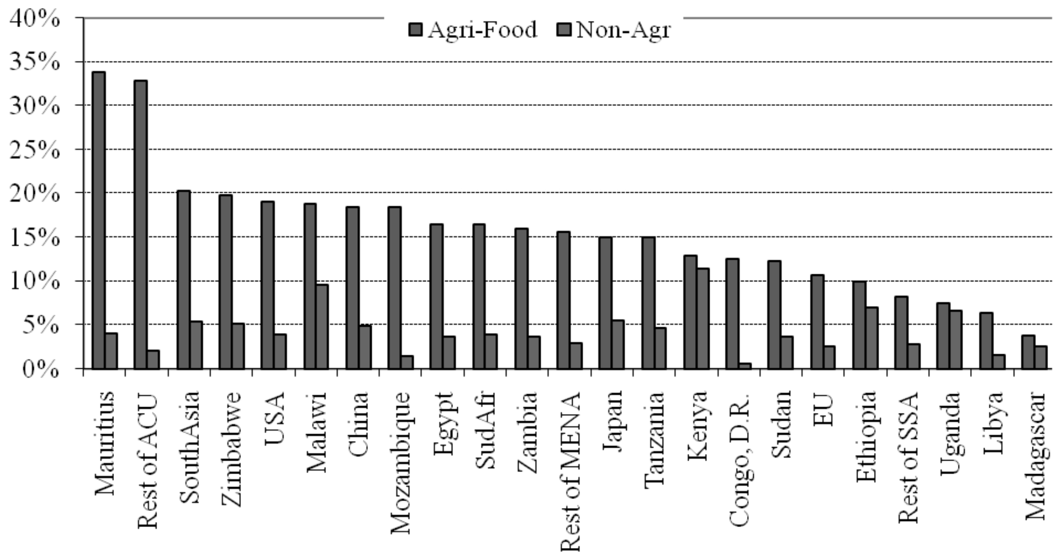
Improving rural road networks is essential to promote social and agricultural development and reduce transaction costs. Only through well-maintained roads can rural areas become less isolated. While many studies have shown public expenditure on agriculture, especially on agricultural R&D, to yield high returns, the similar literature also finds high returns from infrastructure investments, especially in rural roads. According to Fan (2008), in India roads had the largest poverty reduction impact per million rupees spent (lifting 123.8 people out of poverty); agricultural R&D was second (84.5), education a distant third (41), and no other expenditure came close (including antipoverty programs). The same three foci are found to have similarly high returns in China in terms of rural GDP growth and agricultural GDP growth; roads and education also brought high returns in nonfarm GDP. Similar results were found in Thailand for roads and agricultural R&D. Studies in African countries show a similar picture. For example, a study in Uganda found that a million shillings spent on agricultural R&D lifted the most people out of poverty (58.39), followed by feeder roads (33.77), while education again came a distant third (12.81) (see Table 3.6, p. 85, in Fan 2008); Fan, Nyange, and Rao (2003) report similar results for Tanzania. A recent study by Bird, McKay, and Shinyekwa (2007) also found that physical isolation and poor infrastructure are leading causes of poverty in Uganda.

The importance of rural roads can scarcely be overemphasized. Roads are *literally* the foundation of rural development in that good road networks lower the costs of everything else: rural electrification, irrigation, fertilizers, education and health services, agricultural extension services, financial services, output markets, and a whole host of other goods and services, all of which produce dynamic linkages to new opportunities for migration, investment, and trade. Physical infrastructure investments in rural Africa are a necessary condition for agricultural growth and overall rural development.

Reducing Policy and Institutional Barriers to Agricultural Trade

Over the last 20 years developing countries, including countries in Africa, have made great strides in reducing price distortions against their own agriculture sectors, largely by realigning their exchange rates and liberalizing trade (Anderson 2008). The remaining distortions against agriculture largely take the form of tariff and nontariff barriers to imports in developed and developing countries. As Figure 11 demonstrates, tariffs against agricultural products are generally high both within Africa and also in developed countries, and agricultural tariffs are much higher than nonagricultural tariffs. However, there is still some debate as to how much these distortions cost poor countries. Hertel et al. (2006) use detailed data on farm incomes to show that major commodity programs in developed countries are highly regressive, and that the only serious losses under Doha-type trade reform are among wealthy farmers in a few heavily protected subsectors of developed countries. In contrast, analysis of household data from 15 developing countries indicates that reforming rich countries' agricultural trade policies would lift large numbers of farm households in developing countries out of poverty. In the majority of cases such gains are not outweighed by the poverty-increasing effects of higher food prices among other households. Finally, Hertel et al.'s analysis also finds that maximal trade-led poverty reductions occur when developing countries participate more fully in agricultural trade liberalization.

Figure 11. Agricultural tariffs are still high



Source: Calculated by Dimaranan and Mevel (2008) from 2004 MAcMap database. Averages are unweighted.

The recent rise in food prices has prompted several African countries to reduce and even eliminate tariffs on food imports. But other countries, such as Uganda, argue that tariffs on key staples have helped promote more agricultural growth (Zachary 2008). Many poor countries also have weak fiscal systems and rely on tariffs for public revenue, while the predominance of poor people in rural areas also motivates governments to protect poor farmers. Moreover, whereas average tariffs are reasonably low, tariffs on particular products can be quite high, often without much rationale. Tariffs also limit the scope of the market for small African countries, increasing the costs of regional trade and reducing market access, which is especially costly for areas of high food insecurity in Africa.

6. CONCLUSIONS

Rising international food prices pose a serious threat to as well as an opportunity for Africa's food security and future growth prospects. This paper has proposed that the two most important components of a strategy to use the situation as an opportunity are continentwide policy actions aimed at simultaneously accelerating African staples productivity and expanding market access. We have subjected this hypothesis to a rigorous simulation analysis. Based on the analysis, the two-pronged staples-led growth strategy can be expected to achieve the following outcomes:

- ***Increased food security—***Africa's dependency on cereal imports will decline by a third, and Africa will move from deficit to surplus in a number of other important staples, such as maize, roots, and tubers. Food prices will decline but will decline by more than 25 percent for consumers and only around 10 percent for producers, which ensures that farmers will have strong incentives to sustain productivity growth. The availability of food will increase by more than 50 percent in the region and more than 70 percent if in conjunction with greater regional integration to facilitate trade between food-surplus and food-deficit countries. Thus, Africa will become much more food secure.
- ***New market opportunities for staples—***Surpluses created from rapid productivity growth will expect to open up new export markets for African farmers, as well as new opportunities for private investments in modernized agroprocessing and livestock sectors that use staples as inputs.
- ***Increased farmer revenues—***Increased productivity in conjunction with greater market access means that producer prices will decline less than consumer prices, which increases farmer revenue from major staples by $40 billion.
- ***Broader economic transformation—***Rapid growth in staples productivity *w*ill catalyze broader economic growth in African economies through increased demand for nonagricultural goods and services, expanding the scope of markets through international trade and facilitated technological spillovers. The annual growth rate in GDP for the 17 countries as a whole rises to 7.1 percent, and will further increase to 7.7 percent with more integrated regional markets.
- ***Large-scale poverty reduction—***A staples-led strategy can be expected to lift more than 100 million Africans out of poverty, precisely because food consumption is so important to Africa's poor and food production is largely concentrated among poor African smallholders.

Skeptics might justifiably ask whether these results—accelerating staples production growth in conjunction with very large improvements in market access—are really feasible. Indeed, the objective of simulation analysis is not to predict what will be most likely to happen in the next five years but rather to demonstrate how the world might look if policymakers were to take alternative and scaled-up actions. In this vein, the simulation results can be regarded as providing useful benchmarks. Full regional integration, for example, will be most unlikely to be achieved within five years, but the results show that moving in that direction is indeed a worthwhile goal.

Finally, the most important response to skeptics is that there are feasible policy actions that can move Africa a long way toward achieving the aforementioned outcomes. The most important interventions involve a range of scaled-up actions chiefly targeted at modernizing smallholder production and improving market access for both rural and urban populations. An appropriate set of policy actions consists of the following:

- ***Accelerating public investment and strengthening public provision—***This includes a range of public investments and other policy actions to facilitate the use of a modernization package for agriculture: high-yielding seed varieties, irrigation, fertilizers, and pesticides. Whilst this is a combination of inputs that has been validated by Asian experience, existing research also finds that Africa stands to benefit substantially from precisely these types of investments (Johnson, Hazell, and Gulati 2003). The public investment in agriculture required to support the rapid agricultural growth is estimated to be about US$38 billion in total or US$7.8 billion per annum. If current government spending patterns continue, the outlay will not be sufficient for achieving the accelerated growth discussed in this paper. On the other hand, achieving the CAADP 10 percent targets would provide more than 80 percent of the required expenditure, meaning that the remaining investments could feasibly be financed from donors, foreign direct investment, nongovernmental organizations, and other sources.

- ***Investing in transport corridors and local rural infrastructure—***Africa's largest transport corridors already have the potential to promote trade and migration among millions of Africans, but they require improvements in the physical quality of roads and ports, as well as a range of regulatory reforms. Local rural infrastructure also needs to be extended to access more isolated populations.
- ***Reducing trade barriers—***Relative to nonagricultural goods, trade barriers for agricultural goods are still high in Africa and the rest of the world. With improvements in rural infrastructure, reductions in trade barriers would provide strong incentives for African smallholders to increase production and would reduce food prices for urban consumers.

Without these actions the average African farmer will continue to eke out a subsistence living just as his or her forebears did, even as shrinking farm sizes, declining land quality, and an increasingly adverse climate force most of his or her children to seek out informal work in overcrowded urban slums, where the vagaries of the weather are replaced by the vagaries of international food prices. In both cases, hunger and hard living will continue to be the norm. This course is not inevitable, however, precisely because the policy actions described above can make a decisive difference. Amidst equally unfavorable circumstances almost four decades ago, underdeveloped Asia radically changed its course for the better. Africa has at least as much natural potential and human capacity as Asia had before its transformation, but the missing ingredient thus far has been the political will and financial muscle of both African and international policymakers. This urgently needs to change.

APPENDIX A: MATHEMATICAL DESCRIPTION OF THE ECONOMYWIDE MULTIMARKET MODEL FOR SUB-SAHARAN AFRICAN ECONOMIES

The economywide multimarket (EMM) model for Sub-Saharan Africa is based on neoclassical microeconomic theory; it includes 17 Sub-Saharan African countries (Angola, Cameroon, Ethiopia, Ghana, Kenya, Liberia, Madagascar, Malawi, Mali, Mozambique, Nigeria, Rwanda, Senegal, Sierra Leone, Tanzania, Uganda, and Zambia) and three sub-African regions (rest of East Africa, rest of Southern Africa excluding South Africa, and rest of West Africa), such that the entirety of Sub-Saharan Africa (excluding South Africa) is covered in the study. The model includes 15 agricultural commodities or commodity crops and two aggregate nonagricultural activities (livestock production and nonagricultural production). The agricultural commodities are maize, rice, sorghum, millet, wheat, barley, other cereals, cassava, yams, other roots, oil crops, pulses, other crops, poultry, and other livestock, and the nonagricultural sectors are industry and services.

Supply Functions

Consistent with most multimarket model setups, the supply function, instead of the production function, is used to capture producers' responses to market prices and growth in productivity. The supply functions for crop production contain two components: (1) yield functions that are used to capture supply response to own prices given farm area allocated to the particular crop and growth in yield; and (2) land allocation functions that are functions of all prices and hence are responsive to changing profitability across different crops given the total available land.

The yield function (for crops) is given by

$$Y_{R,i,t} = \mathrm{YA}_{\mathrm{R,i,t}} P_{R,i,t}^{\alpha_{R,i}}, \tag{1}$$

where $Y_{R,i,t}$ is the yield for crop *i* in country/region *R* at time period *t*, and $P_{R,i,t}$ is the producer price for *i* and can be different across countries. $\alpha_{R,i}$ is the supply elasticity of the own price. $YA_{R,i,t}$ is the productivity shift parameter, which changes exogenously over time:

$$\mathrm{YA}_{R,i,t+1} = \mathrm{YA}_{\mathrm{R,i,t}}\left(1+g_{Y_{R,i}}\right), \tag{2}$$

where $g_{Y_{R,i}}$ is the annual productivity growth rate in yield, which is exogenous in the model.
The *area function (for crops)* is given by

$$A_{R,i,t} = \mathrm{AA}_{\mathrm{R,i,t}} \prod_j P_{R,j,t}^{\beta_{R,j}}, and \sum_j^J \beta_{R,j} = 0, \tag{3}$$

where $A_{R,i,t}$ is the area for crop *i*, and P_1, P_2, … P_J, is the vector of producer prices for all commodities (including the two nonagricultural sectors); $\mathrm{AA}_{R,i,t}$ is the shift parameter, which captures the area expansion:

$$\mathrm{AA}_{R,i,t+1} = \mathrm{AA}_{\mathrm{R,i,t}}\left(1+g_{A_{R,i}}\right), \tag{4}$$

where $g_{A_{R,i}}$ is the annual area expansion rate for crop *i*, which is assumed exogenous in order to capture historical crop- and country-specific trends. Given that many prices are endogenous in the model, area functions, similar to the supply functions for noncrop production, capture cross-sector linkages among crops, between crop and noncrop agriculture (such as livestock), and between agriculture and nonagriculture through the price elasticities, $\beta_{R,i}$, which is for the own- and cross-price elasticities. The *total supply of crops* is given by

$$S_{R,i,t} = \sum Y_{R,i,t} \cdot A_{R,i,t} \,. \tag{5}$$

The *supply function for noncrop sectors (livestock and nonagriculture)* is given by

$$S_{R,i,t}^{LV} = \mathrm{SA}_{\mathrm{R,i,t}}^{\mathrm{LV}} \prod_j P_{R,j,t}^{\beta_{R,j}^{LV}} \,. \tag{6}$$

*Trends in the livestock and nonagricultural supply functio*n are represented by

$$\mathrm{SA}_{\mathrm{R,i,t+1}}^{\mathrm{LV}} = \mathrm{SA}_{\mathrm{R,i,t}}^{\mathrm{LV}} \left(1 + g_{S_{R,i}}\right), \tag{7}$$

where $g_{S_{R,i}}$ is the annual growth rate of livestock and nonagricultural productivity and varies by country and commodity. As we mentioned above, g_Y, g_A, and g_S are all exogenous in the model. $\beta_{R,i}^{LV}$ is the output own- and cross-price elasticities.

Own-Price and Cross-Price Supply Elasticities

It is almost impossible to estimate supply elasticities for all agricultural commodities across 17 countries based on historical data. Thus, own-price elasticity in the supply functions is drawn from the literature and is assumed to be the same in the supply function of a similar commodity across countries. According to an intensive literature review done by You and his assistant under IFPRI's project Dynamic Research Evaluation for Management (DREAM), own-price elasticities in the supply function for those agricultural commodities that are also included in our model vary between 0.1 and 1.5 in the short run. The values can reach as high as 2.4 or 4.1 in the long run for maize and wheat, respectively. The former value is estimated for large maize farmers in Kenya by Maitha (1974) during the period 1950–1969 through acreage response. In the same country, Liu and Romingen[7] (1985) determined the supply elasticity of wheat to be 4.1 through direct estimation of the supply function using 1964–1979 data.

Estimation in short-run supply response in the literature reveals a diverse outcome. With regard to rice, for example, the short-run elasticities range from 0.11 as reported in Rojko et al. (1978) for Sierra Leone to 0.484 for Kenya according to Sarris and Freebairn (1983). Sarris and Freebairn (1983), using the grains, oilseeds, and livestock model, also calculated the long-run elasticity of rice in Kenya, and it equals 1.363. For sorghum, Davis, Oram, and Ryan (1987) reported short-run supply elasticity around 0.10 in Sub-Saharan Africa, while Medani (1970) provided an upper range of 0.31 in Sudan using acreage responses for the period 1951–1965. Medani also came up with a 0.09 and 0.36 short- and long-run elasticity of millet in Sudan, respectively, while Davis, Oram, and Ryan (1987) provided a value of 0.40 as supply elasticity for pulses in Sub-Saharan Africa. Relying on expert estimates, Rosegrant et al. (2001) indicated that in the same region, elasticity for cassava is 0.15, while that for poultry is 0.30. Based on Frohberg and Kromer (1985),[8] supply elasticity for root crops and other cereals (excluding rice) is 0.10.

Based on the literature reviewed, we decided to have a similar own-price elasticity in both yield and area functions across commodities and countries (see Appendix Table C.1). After that, the negative cross-price elasticities in the area (or supply) function are derived from the own-price elasticity multiplied by the value share of each commodity at the national level (with a negative sign). The homogeneity of degree zero condition is imposed on the supply function such that, within each time period, there is no supply response if all prices change proportionally. The constraint on crop area function is also imposed to avoid a simultaneous expansion of all crop areas over a given time period due to price response. The

[7] As cited by Henneberry (1986) in Appendix VI.
[8] As cited by Henneberry (1986) in Appendix VI.

elasticities in the area (supply) functions for agricultural production averaged over the 17 countries are reported in Appendix Table C.2. While there is similar own-price elasticity in supply functions for a same crop across countries, due to differences in crop patterns between the countries, the cross-price elasticities differ across countries, which results in a country-different supply response to a similar change in a commodity price.

Demand Functions

The country-level demand function for each good is derived from maximizing a Stone-Geary type of utility function. The actual function used in the model is dependent on all prices and income. It is determined as follows:

$$DC_{R,i,t} = \prod_j PC_{R,j,t}^{\varepsilon_{R,i,j}} GDP_{R,t}^{\varepsilon_{R,i}^I}, \tag{8}$$

where $DC_{R,I,t}$ is the demand for commodity *i* in country *R*, and $PC_{R,j,t}$ is the consumer price for *j* in country *R*. *j* = 1,2,…,17 (including two aggregate nonagricultural goods). $GDP_{R,t}$ is total income (GDP) for country *R*. $\varepsilon_{R,i,j}$ is the price elasticity between demand for commodity *i* and price for commodity *j*, and $\varepsilon_{R,i}^I$ is income elasticity for commodity *i*.

The income elasticity is evaluated using Ghana's recent household survey data (GLSSV 2005/06) at the sample means of all households, and the coefficients to calculate the elasticity are estimated from a semi-log inverse function (RSLI) suggested by King and Byerlee (1978). The price elasticities are then derived from the linear expenditure of demand solved from maximizing the Stone-Geary utility function such that the budget constraint is satisfied for each demand function. That is: $\sum_j^J \varepsilon_{R,Z,i,j} + \varepsilon_{R,Z,i}^I = 0,$ and $\sum_j^J sh_{R,Z,j} \cdot \varepsilon_{R,Z,j}^I = 1,$ where $sh_{R,Z,i}$ is the expenditure share of commodity *i*. Income and price elasticities in demand function are reported in Appendix Tables C.3 and C.4.

Due to lack of household survey data for many countries, we assume that the income elasticity for each commodity is the same across 17 countries/regions, while price elasticities for any specific commodity vary across countries due to different consumption patterns at the country level. However, income elasticity is different for different commodities, and these variations across commodities affect the ratio of subsistence consumption over market demand for a specific commodity. Moreover, the variations in consumption patterns across countries affect the average budget share of each commodity in total expenditure. These two factors determine that for a similar change in prices or income, changes in the demand for a specific commodity are different across commodities and between countries. For a commodity with a large budget share (i.e., a staple crop such as maize or cassava), both income and own-price elasticities in the demand function are low relative to other commodities with smaller initial budget shares but higher income elasticities (such as poultry).

Exports, Imports, and Producer and Consumer Prices

As the name of the model suggests, a multiple market structure is specified. There is perfect substitution between domestically and internationally produced commodities. Transportation and other market costs or barriers, however, distinguish prices for domestically traded products from imports and exports. Moreover, trade (either in imports or exports) is determined by the difference between national market prices and import/export parity prices (in which transportation and trade margins are taken into consideration). For example, while imported maize can perfectly substitute with domestically produced maize in consumers' demand functions, maize may still not be profitable to import if its domestic price is lower than the import parity price less transaction costs and other trade barriers. Maize imports can occur only when domestic demand for maize grows faster than domestic supply and the local market price rises significantly. A similar situation applies to exported commodities. Even though certain horticultural products are exportable, if domestic production is not competitive in international markets, either due to low productivity or high transaction costs, then exports will not be profitable. Only when domestic producer prices plus market costs are lower than the export parity price of the same product does it become profitable to export. Moreover, an initial imported commodity, such as rice, can become exportable if the domestic rice price falls to the level of the export parity price minus export margins after significantly rising rice productivity.

In this study, we also assume the existence of transportation margins between producer and consumer prices, such as

$$PC_{R,i,t} = \left(1 + Dm_{R,i}\right) \cdot P_{R,i,t}, \tag{9}$$

where $PC_{R,i,t}$ is consumer price and $P_{R,i,t}$ producer price in domestic market R for commodity i; $Dm_{R,i}$ is the domestic marketing margin between consumer and producer prices, and can vary by country. The relationship between import parity prices and consumer prices is defined as

$$PC_{R,i,t} \le \left(1 + Wmt_{R,i}\right) \cdot PWM_{R,i}, \quad M_i > 0 \text{ if “=”} \tag{10}$$

where $Wmt_{R,i}$ is the marketing margin between the country’s CIF prices, $PWM_{R,i}$, and consumer prices, $PC_{R,i,t}$, in domestic markets for commodity i. When $PC_{R,i,t}$ is less than $\left(1 + Wmt_{R,i}\right) \cdot PWM_{R,i}$, $PC_{R,i,t}$ is an endogenous price determined by domestic supply and domestic demand. The equation holds only when the imports are positive. In this situation, the domestic price for commodity i in country R exogenously links with its border price. Thus, equation (10) is also a function for imports of i in country R. The relationship between export parity and domestic producer prices is given by

$$P_{R,i,t} \ge \left(1 - Wmt_{R,i}\right) \cdot PWE_i, \quad E_i > 0 \text{ if “=”} \tag{11}$$

where $PWE_{R,i}$ represents export border prices. If $P_{R,i,t}$ is greater than $\left(1 - Wmt_{R,i}\right) \cdot PWE_i$, $P_{R,i,t}$ is an endogenous price determined by domestic supply and demand. The equation holds only when the exports are positive. Thus, equation (11) is also a function for exports of i from country R. The combination of equations (10) and (11) indicates that for any commodity i in country R it is impossible to be both imported and exported in the same time period, although it is possible for an imported (exported) one to switch to an exported (imported) one when the endogenous domestic price for i in country R changes significantly.

Balance of Demand and Supply at the National Level

At the national level, the balance of demand (DC) and supply is given by

$$S_{R,i,t} + M_{R,i,t} - E_{R,i,t} = DC_{R,i,t}. \tag{12}$$

This equation solves for the price of commodity i in country R if both imports (M) and exports (E) are zero (S) is domestic supply. Otherwise, it solves for the value of M or E.

Income (GDP) Function

Income in the model is endogenous and determined by production revenues. Given that the model does not explicitly include inputs, producer prices are adjusted to represent value added, and hence, the aggregation of agricultural production equals agricultural GDP. For the two nonagricultural sectors, the sector-level GDP is used to represent production output with unit price. Thus, national GDP comprises agricultural GDP and nonagricultural GDP, which are both endogenous in the model. Hence the aggregation of sectoral GDP which represents the income level in the demand function:

$$GDP_{R,t} = \sum_{j} P_{R,j,t} \cdot S_{R,j,t} \ , \tag{13}$$

Simulations of the EMM Model

Two types of simulations are conducted using the EMM model for Africa. In the first scenario, we consider only productivity growth, together with modest land expansion. The total increase in yield by crop and country is calculated based on the yield potential, and such potential is calculated based on the gap between the current actual yield and the yield achieved in the region for some countries (in most cases, in South Africa). The average annual growth rate, $g_{Y_{R,i}}$, is then calculated based on that potential such that $\mathrm{YA}_{R,i,t+1} = \mathrm{YA}_{\mathrm{R,i,t}}\left(1 + g_{Y_{R,i}}\right)$ defined in equation (2) is augmented exogenously for the next five years between 2009 and 2013. The land expansion is based on the historical trends of recent years and varies across countries and crops. Population growth rate affects the rate of land expansion but is not directly included in the model. Only when we report the per capita income and consumption is population growth taken into account. $g_{A_{R,i}}$ and $g_{Y_{R,i}}$ are represented in Appendix Tables C.5 and C.6. It is important to note that due to the price effect and supply responses to the changes in the endogenous prices, the actual growth rates in both yield and area expansion are endogenous model results and are therefore different from the initial exogenous “shocks” to output and land expansion ($g_{Y_{R,i}}$ and $g_{A_{R,i}}$). The model results for the first simulation are presented in Appendix Tables A7 and A8.

In the second type of simulation we try to capture the effects of increasing market access. In this scenario, in addition to the shocks imposed in the first simulation, we assume that similar regional prices penetrate markets across the region, such that the domestic price for a similar commodity is the same across countries expressed in U.S. dollars. Specifically, equation (12) is now defined at the regional instead of the national level—that is,

$$\sum_{R} (S_{R,i,t} + M_{R,i,t} - E_{R,i,t}) = \sum_{R} DC_{R,i,t} \ . \tag{12′}$$

A single price for commodity *i*, instead for it in each country *R*, can be solved from equation (12′). Market integration is often an outcome of the removal of tariff, nontariff, and other institutional barriers, as well as improvements in cross- and within-country transportation conditions. Because of this, in the second simulation we further assume that the market margin between producer and consumer prices in each domestic market, which is 40 percent of the producer prices, is lowered by 15 percent annually. This implies that the gap between the domestic consumer and producer price is lowered from 40 percent to 18 percent of the producer price by the end of the next five years. With this model setup and assumptions, consumer prices still fall considerably as comparable with that in the first simulation, but producer prices fall much less, as we have discussed in the main text of the paper. The public investment cost related to the market integration and improvements in cross- and within-country transportation, however, is not calculated in the model because of the lack of enough information and data.

Limitations of the EMM Model

Like any other economic model, the EMM model has its limitations, especially when compared with a standard general equilibrium model (e.g., computable general equilibrium [CGE] models). Of the limitations, there are at least four important ones. First, the model does not include government income and expenditure or policy instruments and investment activities. These issues are therefore discussed separately in Section 5 (Appendix B provides additional details), where we employ econometrically derived elasticities for agricultural growth and public expenditure on agriculture from existing literature.

Second, unlike country-specific models, the current EMM model does not directly assess within-country differentiations in both production and consumption. The within-country poverty impacts, including the impacts on subgroups such as net food consumers or net food producers, cannot be analyzed using the current version of the EMM model. In Section 4 we therefore adopt a second-best approach by estimating the impact of our EMM-derived agricultural growth rates on poverty reduction through a series of growth–poverty reduction elasticities defined at the country level and drawn from the existing literature (Appendix B provides additional details).

Third, one of the key channels to generate economywide linkages in a general equilibrium model is through factor mobility and demand on intermediate inputs. These types of linkages are ignored in the EMM model due to the absence of a production-and-demand-for-inputs specification in the model. Aside from land, the model does not take into consideration the use of labor, capital, and other purchased inputs in production, including capital accumulation. For example, one would expect that the doubling of staples production will initially require drawing resources (capital, labor) away from the livestock and nonagricultural sectors. In the longer term, however, staples growth in agriculture can actually have positive multiplier effects on these sectors (Delgado, Hopkins, and Kelly 1998). Linkages between staples growth and the livestock sector are discussed further below. As for labor, the effect of rapid staples-led growth on sectoral labor supplies and migration decisions is quite ambiguous. Intersectoral migration depends on a number of factors, including intersector differentials in growth rates, labor intensities, and income volatilities, as well as a range of more complex economic and noneconomic factors (Todaro 1997). Modeling these complex decisions is beyond the scope of an EMM model, and certainly one limitation of its use.

Although land allocation is included in the EMM model, the ability to reallocate land is relatively more rigid than in a CGE model because of the model's use of supply functions instead of production functions. While resource immobility may be a problem in a dynamic model focusing on long-run structural change, given that the EMM model is used for simulations over the next six to seven years, we are less concerned by this shortcoming. Moreover, we do not expect that a staples-led growth strategy would attract a substantial amount of additional resources for two reasons. First, the additional growth in output is assumed to be driven by rapidly rising staple crop yields rather than increased use of resources. Second, output growth in staples will always remain constrained by the demand side. Productivity growth in staples is expected to actually release more resources (e.g., land) from staples production to other crop production such as high-value export crops. This explains the observed strong multiplier effects of the food staples sector for overall economic growth (see Diao et al. 2007).

Sensitivity Tests on the Supply and Demand Elasticities of the EMM Model

In a CGE model, due to full general equilibrium linkages, the inclusion of factor endowments, together with the assumption of imperfect substitution between domestically produced and consumed goods and imported and exported goods, the simulation results of the model are usually not sensitive to the choice of elasticities in the production and demand equations. However, in an EMM model, as with any other simulation model with reduced-form supply and demand functions, the simulation results are often sensitive to the choice of elasticities in the supply and demand functions. As we discussed earlier, the supply elasticity is mainly drawn from literature, while the income elasticity in demand is estimated using Ghana's household-level data. This income elasticity, combined with expenditure shares by commodity across countries, is used to calculate price elasticities in the demand function such that the summation of these elasticities satisfies standard conditions imposed by economic theory. However, supply elasticities are often independently estimated for individual commodities in the literature and are often quite country specific. On the demand side, the income elasticity applied in our model is not estimated country by country due to data constraints. For these reasons, a series of sensitivity tests are conducted to justify the model results. For brevity's sake, we report only the results of the sensitivity tests for the price effects (i.e., those presented in Figure 4 in the main text), which are based on different choices of elasticities in the demand function (see Appendix Table A.9).

The conclusion of the sensitivity tests is that the model results are not sensitive to the choice of supply elasticities, which vary in a range of –50 percent to +50 percent of the value applied in the model, or the choice of income elasticities in the demand function when it is income inelastic (with a value less than one) and varies in a range of –25% to +25% of the value applied in the model. However, the model results (particular changes in the prices) are sensitive to the choice of income elasticity switching from income elastic to income inelastic and vice versa. That is to say, if rice or poultry becomes an income-inelastic commodity as the value of income elasticity in its demand function changes from greater than 1 to less than 1, the price of rice or poultry can fall much more if its demand becomes income inelastic, while it can fall much less and even rise if the demand becomes very income elastic. The difference in terms of the change in rice price between these two cases can be four times, and the price of poultry can even rise when its demand becomes very income elastic. Given that demand for most agricultural products is income inelastic, we have less concern for these extreme cases that apply only to a very few commodities, such as rice, wheat, and livestock in Africa.

APPENDIX B: CALCULATION OF REQUIRED PUBLIC INVESTMENT IN AGRICULTURE AND EXPECTED POVERTY REDUCTION

Reported results of the public investment in agriculture required to achieve the expected growth rate, as well as the extent of poverty reduction predicted by such rapid agricultural growth, are not drawn from within the EMM model. Instead, we linked the model results at the individual-country level with (a) elasticities of agricultural growth with respect to public investment to calculate the required agricultural spending, and (b) elasticities of poverty reduction with respect to agricultural GDP growth to estimate the extent of poverty reduction predicted by growth acceleration. For the methodology to derive the elasticities of agricultural growth with respect to public investment we draw from Fan (2008), and for the calculation of poverty reduction we take into consideration both the direct and the indirect impacts of growth (Diao et al. 2007; Christiaensen, Demery, and Kühl 2006).

The level of public expenditure is determined by agricultural growth, and such growth is endogenously obtained in our model. The elasticity of agricultural growth with respect to public investment is drawn from Fan (2008) and is assumed to be the same across countries (with a value of 0.318). Current-level public spending on agriculture and its share in total government spending are reported in Appendix Table C.10.

The rate of poverty reduction is also determined by agricultural GDP growth derived from our model. The elasticities of poverty reduction with respect to GDP growth came from different sources. For instance, using a series of economywide models, Diao et al. (2007) derive an elasticity of poverty reduction with respect to agricultural GDP of –1.66 for Ethiopia, –1.78 for Ghana, –1.25 for Kenya, –1.58 for Uganda, and –0.58 for Zambia. For the other countries where our own estimation is unavailable, we draw from recent Africa-wide estimates of Christiaensen, Demery, and Kühl (2006) indicating that the elasticity of poverty reduction with respect to agricultural GDP in low-income countries for Africa is –1.83. It can be seen that despite differences in the methods, the elasticities estimated by Diao et al. (2007) are comparable with those by Christiaensen, Demery, and Kühl for the low-income countries. Appendix Table C.10 shows the current poverty rate by country.

APPENDIX C: SUPPLEMENTARY TABLES

Table C.1. Own-price elasticity in agricultural supply function

Commodity	Elasticity
Maize	0.40
Rice	0.40
Sorghum	0.40
Millet	0.40
Wheat	0.40
Barley	0.40
Other cereals	0.47
Cassava	0.52
Yam	0.45
Other roots	0.40
Oil crops	0.40
Pulses	0.40
Other crops	0.40
Poultry	0.50
Other livestock	0.40

Source: Results are derived from literature review.
Note: The elasticities are for crop production aggregated over yield and area functions, and averaged over 17 countries.

Table C.2. Own- and cross-price elasticity in agricultural supply function (average over 17 countries)

	Maize	Rice	Sorghum	Millet	Wheat	Barley	Other cereals	Cassava
Maize	0.200	-0.015	-0.010	-0.006	-0.007	-0.001	-0.003	-0.026
Rice	-0.017	0.200	-0.009	-0.008	-0.001	0.000	-0.001	-0.022
Sorghum	-0.021	-0.017	0.200	-0.008	-0.005	-0.001	-0.003	-0.028
Millet	-0.019	-0.024	-0.013	0.200	-0.002	0.000	-0.001	-0.025
Wheat	-0.040	-0.003	-0.013	-0.003	0.200	-0.006	-0.014	-0.008
Barley	-0.041	-0.001	-0.014	-0.003	-0.031	0.200	-0.019	0.000
Other cereals	-0.037	-0.005	-0.014	-0.004	-0.027	-0.007	0.200	-0.003
Cassava	-0.031	-0.024	-0.016	-0.009	-0.002	0.000	0.000	0.270
Yam	-0.021	-0.026	-0.016	-0.014	0.000	0.000	-0.001	-0.038
Other roots	-0.029	-0.015	-0.011	-0.005	-0.008	-0.002	-0.004	-0.027
Oil crops	-0.020	-0.021	-0.012	-0.009	-0.002	0.000	-0.001	-0.029
Pulses	-0.028	-0.017	-0.012	-0.007	-0.007	-0.002	-0.004	-0.024
Other crops	-0.025	-0.017	-0.012	-0.007	-0.004	-0.001	-0.002	-0.029
Poultry	-0.082	-0.035	-0.064	-0.041	-0.011	-0.005	-0.013	0.000
Other livestock	-0.066	-0.028	-0.051	-0.033	-0.009	-0.004	-0.010	0.000

Table C.2. Continued

	Yam	Other roots	Oil crops	Pulses	Other crops	Poultry	Other livestock
Maize	-0.007	-0.010	-0.029	-0.008	0.000	0.087	0.070
Rice	-0.010	-0.005	-0.033	-0.005	0.000	0.149	0.119
Sorghum	-0.012	-0.008	-0.037	-0.008	0.000	0.038	0.031
Millet	-0.016	-0.006	-0.045	-0.007	0.000	0.030	0.024
Wheat	-0.001	-0.014	-0.012	-0.011	0.000	0.061	0.048
Barley	-0.001	-0.017	-0.007	-0.013	0.000	0.021	0.017
Other cereals	-0.003	-0.015	-0.013	-0.012	0.000	0.043	0.034
Cassava	-0.016	-0.011	-0.050	-0.009	0.000	0.000	0.000
Yam	0.250	-0.008	-0.061	-0.008	0.000	0.000	0.000
Other roots	-0.008	0.200	-0.028	-0.010	0.000	0.000	0.000
Oil crops	-0.015	-0.007	0.200	-0.007	0.000	0.000	0.000
Pulses	-0.010	-0.011	-0.032	0.200	0.000	0.000	0.000
Other crops	-0.008	-0.009	-0.035	-0.008	0.200	0.000	0.000
Poultry	0.000	0.000	0.000	0.000	0.000	0.500	-0.101
Other livestock	0.000	0.000	0.000	0.000	0.000	-0.014	0.400

Source: Calculated based on literature review

Table C.3. Income elasticity in the demand function

Commodity	Elasticity
Maize	0.55
Rice	1.10
Sorghum	0.50
Millet	0.55
Wheat	1.10
Barley	0.45
Other cereals	0.45
Cassava	0.55
Yam	0.48
Other roots	0.50
Oil crops	0.75
Pulses	0.60
Other crops	0.90
Poultry	1.45
Other livestock	0.98
Industry	1.07
Services	1.10

Source: Estimated using Ghana's recent household survey (GLSSV, 2005/06) data.

Table C.4. Price elasticity in the demand function (average over 17 countries)

	Maize	Rice	Sorghum	Millet	Wheat	Barley	Other cereals	Cassava	Yam
Maize	-0.470	-0.003	-0.004	-0.002	-0.003	-0.002	-0.003	-0.008	-0.002
Rice	-0.006	-0.953	-0.006	-0.005	-0.002	-0.001	-0.001	-0.015	-0.006
Sorghum	-0.004	-0.003	-0.424	-0.003	-0.002	-0.001	-0.002	-0.009	-0.003
Millet	-0.003	-0.004	-0.004	-0.470	-0.002	-0.001	-0.001	-0.007	-0.004
Wheat	-0.011	-0.005	-0.012	-0.004	-0.929	-0.003	-0.006	-0.017	-0.005
Barley	-0.008	-0.001	-0.006	-0.001	-0.006	-0.373	-0.009	0.000	0.000
Other cereals	-0.007	-0.001	-0.006	-0.002	-0.005	-0.004	-0.379	-0.001	-0.001
Cassava	-0.004	-0.003	-0.004	-0.002	-0.002	0.000	0.000	-0.479	-0.004
Yam	-0.002	-0.003	-0.003	-0.003	-0.001	0.000	0.000	-0.008	-0.414
Other roots	-0.005	-0.002	-0.004	-0.002	-0.002	-0.001	-0.002	-0.008	-0.002
Oil crops	-0.004	-0.005	-0.006	-0.004	-0.002	0.000	0.000	-0.013	-0.006
Pulses	-0.006	-0.003	-0.005	-0.003	-0.003	-0.001	-0.002	-0.009	-0.003
Other crops	-0.007	-0.005	-0.008	-0.004	-0.004	-0.001	-0.001	-0.017	-0.004
Poultry	-0.010	-0.011	-0.008	-0.006	-0.004	-0.001	-0.002	-0.020	-0.006
Other livestock	-0.008	-0.006	-0.009	-0.004	-0.004	-0.001	-0.003	-0.015	-0.003
Industry	-0.005	-0.005	-0.006	-0.004	-0.002	0.000	-0.001	-0.015	-0.007
Services	-0.008	-0.008	-0.007	-0.004	-0.003	-0.001	-0.002	-0.015	-0.005

Table C.4. Continued

	Other roots	Oil crops	Pulses	Other crops	Poultry	Other livestock	Industry	Services
Maize	-0.004	-0.004	-0.001	0.000	0.000	-0.005	-0.018	-0.021
Rice	-0.004	-0.011	-0.002	0.000	-0.001	-0.007	-0.038	-0.042
Sorghum	-0.003	-0.005	-0.001	0.000	0.000	-0.004	-0.019	-0.016
Millet	-0.002	-0.006	-0.001	0.000	0.000	-0.003	-0.023	-0.017
Wheat	-0.009	-0.009	-0.003	0.000	-0.001	-0.011	-0.036	-0.038
Barley	-0.008	-0.001	-0.003	0.000	0.000	-0.006	-0.008	-0.018
Other cereals	-0.007	-0.002	-0.003	0.000	0.000	-0.006	-0.009	-0.018
Cassava	-0.003	-0.005	-0.001	0.000	0.000	-0.004	-0.023	-0.017
Yam	-0.002	-0.006	-0.001	0.000	0.000	-0.002	-0.024	-0.012
Other roots	-0.426	-0.004	-0.002	0.000	0.000	-0.004	-0.017	-0.017
Oil crops	-0.003	-0.645	-0.001	0.000	0.000	-0.005	-0.030	-0.024
Pulses	-0.005	-0.005	-0.508	0.000	0.000	-0.005	-0.021	-0.021
Other crops	-0.006	-0.009	-0.002	-0.759	-0.001	-0.008	-0.031	-0.032
Poultry	-0.006	-0.013	-0.003	0.000	-1.242	-0.010	-0.053	-0.055
Other livestock	-0.006	-0.009	-0.002	0.000	-0.001	-0.835	-0.032	-0.036
Industry	-0.004	-0.008	-0.002	0.000	-0.001	-0.005	-0.980	-0.029
Services	-0.005	-0.009	-0.002	0.000	-0.001	-0.008	-0.040	-0.983

Source: Calculated based on consumption pattern and income elasticity.

Table C.5. Annual area expansion rate applied to the area coefficient in the model

	Maize	Rice	Sorghum	Millet	Wheat	Barley	Other cereals	Cassava	Yam	Other roots	Oil crops	Pulses	Other crops
Angola	3.1	4.5	0.0	4.3	4.5	0.0	0.0	4.5	0.0	4.5	4.5	4.5	4.5
Cameroon	1.7	4.4	1.7	1.7	4.4	0.0	0.0	1.7	1.7	1.7	4.4	1.7	1.7
Ethiopia	1.7	4.4	1.7	1.7	4.4	1.7	1.7	0.0	1.7	1.7	4.4	1.7	2.5
Ghana	1.7	4.4	1.7	1.7	0.0	0.0	1.7	1.7	1.7	1.7	4.4	1.7	2.6
Kenya	1.7	4.5	1.7	1.7	4.5	1.7	1.7	1.7	1.7	1.7	4.5	1.7	1.7
Liberia	0.0	4.4	0.0	0.0	0.0	0.0	1.7	1.7	1.7	1.7	4.4	1.7	2.7
Madagascar	2.1	4.5	2.1	0.0	4.5	0.0	0.0	2.1	0.0	2.1	4.5	2.1	2.1
Malawi	1.7	4.4	1.7	1.7	4.4	0.0	0.0	1.7	0.0	1.7	4.4	1.7	1.7
Mali	2.3	4.5	2.3	2.3	4.5	0.0	2.3	2.3	2.3	2.3	4.5	2.3	2.3
Mozambique	1.7	4.4	1.7	1.7	4.4	0.0	0.0	1.7	0.0	1.7	4.4	1.7	4.5
Nigeria	1.7	4.4	1.7	1.7	4.4	0.0	1.7	1.7	1.7	1.7	4.4	1.7	3.6
Rwanda	1.7	4.4	1.7	1.7	4.4	0.0	0.0	1.7	1.7	1.7	4.4	1.7	2.7
Senegal	1.8	4.5	1.8	1.8	0.0	0.0	1.8	1.8	0.0	1.8	4.5	1.8	1.8
Sierra Leone	3.2	4.5	3.2	3.2	0.0	0.0	3.2	3.2	0.0	3.2	4.5	3.2	3.2
Tanzania	1.7	4.4	1.7	1.7	4.4	1.7	1.7	1.7	1.7	1.7	4.4	1.7	3.0
Uganda	2.7	4.5	2.7	2.7	4.5	0.0	0.0	2.7	0.0	2.7	4.5	2.7	2.7
Zambia	1.7	4.4	1.7	1.7	4.4	1.7	0.0	1.7	0.0	1.7	4.4	1.7	1.7
Rest of East Africa	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
Rest of Southern Africa	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	0.0	2.8	2.8	2.8	2.8
Rest of West Africa	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6

Source: Calculated based on historical trends.

Table C.6. Annual growth rate applied to the yield coefficient in the model

	Maize	Rice	Sorghum	Millet	Wheat	Barley	Other cereals	Cassava	Yam	Other roots	Oil crops	Pulses	Other crops
Angola	11.5	10.9	0.0	10.4	11.7	0.0	0.0	4.2	0.0	2.5	5.1	6.4	2.9
Cameroon	10.2	7.7	11.1	11.1	14.0	0.0	0.0	16.1	16.1	9.6	11.3	3.1	2.2
Ethiopia	9.8	10.3	11.3	11.3	14.2	11.3	11.3	0.0	12.7	12.7	13.2	7.4	2.2
Ghana	13.3	12.2	10.7	10.7	0.0	0.0	10.7	11.0	9.9	8.3	10.0	14.3	2.2
Kenya	14.1	9.2	13.1	13.1	14.2	13.1	13.1	13.7	13.7	11.0	10.9	11.5	2.2
Liberia	0.0	2.2	0.0	0.0	0.0	0.0	11.3	13.4	13.4	10.8	3.7	8.1	2.2
Madagascar	11.7	7.0	3.7	0.0	13.6	0.0	0.0	13.6	0.0	13.6	15.4	4.4	2.8
Malawi	15.7	14.3	11.1	11.1	16.4	0.0	0.0	11.0	0.0	8.8	8.8	10.5	2.2
Mali	16.8	12.3	8.9	8.9	11.5	0.0	8.9	10.2	10.2	8.2	8.0	11.1	3.0
Mozambique	14.7	11.5	10.8	10.8	15.3	0.0	0.0	13.2	0.0	10.6	9.6	12.9	2.2
Nigeria	15.3	14.7	11.9	11.9	14.1	0.0	11.9	13.5	10.6	10.6	13.5	13.4	2.2
Rwanda	15.2	11.2	10.3	10.3	15.0	0.0	0.0	15.0	15.0	10.5	6.9	11.7	2.2
Senegal	2.7	8.4	13.7	13.7	0.0	0.0	13.7	14.6	0.0	11.7	9.1	14.0	2.4
Sierra Leone	9.2	8.5	5.1	5.1	0.0	0.0	5.1	11.8	0.0	11.8	3.1	5.0	4.2
Tanzania	12.8	12.3	10.5	10.5	16.0	10.5	10.5	13.3	12.0	13.3	14.2	13.6	2.2
Uganda	11.6	12.0	11.0	11.0	14.9	0.0	0.0	14.2	0.0	9.9	10.3	11.8	3.5
Zambia	10.1	10.2	8.8	8.8	7.0	8.8	0.0	13.4	0.0	10.7	10.2	12.1	2.2
Rest of East Africa	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Rest of Southern Africa	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	0.0	1.1	1.1	1.1	1.1
Rest of West Africa	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3

Source: Calculated based on growth potential

Table C.7. Crop area and annual growth rate as the model results

	Angola			Cameroon			Ethiopia		
	Crop area (1,000 ha)		Annual growth	Crop area (1,000 ha)		Annual growth	Crop area (1,000 ha)		Annual growth
	Current	By 2013	rate (%)	Current	By 2013	rate (%)	Current	By 2013	rate (%)
Maize	1,333	1,448	1.7	534	548	0.5	2,733	2,779	0.3
Rice	5	6	5.5	18	24	6.2	11	15	5.3
Sorghum				414	425	0.5	2,240	2,270	0.3
Millet	342	393	2.8	45	47	0.7	540	556	0.6
Wheat	3	4	5.5	0	0	6.2	2,261	2,742	3.9
Barley							1,881	1,913	0.3
Other cereals							5,205	5,211	0.0
Cassava	898	1,081	3.8	387	389	0.1			
Yam				38	39	0.5	56	57	0.3
Other roots	273	338	4.4	304	314	0.6	917	934	0.4
Oil crops	1,325	1,639	4.3	4,099	4,763	3.0	4,177	4,986	3.6
Pulses	472	617	5.5	283	319	2.5	2,076	2,262	1.7
Other crops	22	28	5.0	11	12	3.1	28	33	3.8

Table C.7. Continued

	Ghana			Kenya			Liberia		
	Crop area (1,000 ha)		Annual growth	Crop area (1,000 ha)		Annual growth	Crop area (1,000 ha)		Annual growth
	Current	By 2013	rate (%)	Current	By 2013	rate (%)	Current	By 2013	rate (%)
Maize	741	784	1.1	2,262	2,194	-0.6			
Rice	142	192	6.3	17	22	5.7	142	184	5.2
Sorghum	228	237	0.8	265	278	1.0			
Millet	234	245	0.9	119	122	0.5			
Wheat				149	195	5.6			
Barley				15	15	0.1			
Other cereals	0	0	0.8	4	4	0.1	1	1	-0.2
Cassava	770	789	0.5	31	31	-0.1	101	96	-1.0
Yam	328	339	0.7	1	1	-0.2	3	3	-0.7
Other roots	316	336	1.2	149	151	0.3	7	7	0.0
Oil crops	5,153	6,084	3.4	681	812	3.6	225	275	4.1
Pulses	180	191	1.2	1,460	1,524	0.9	7	8	2.5
Other crops	243	297	4.1	44	51	2.9	2	2	3.3

Table C.7. Continued

	Madagascar			Malawi			Mali		
	Crop area (1,000 ha)		Annual growth	Crop area (1,000 ha)		Annual growth	Crop area (1,000 ha)		Annual growth
	Current	By 2013	rate (%)	Current	By 2013	rate (%)	Current	By 2013	rate (%)
Maize	164	170	0.7	1,112	1,097	-0.3	634	658	0.8
Rice	1,372	1,758	5.1	43	52	4.0	594	705	3.5
Sorghum	2	2	2.3	64	70	1.9	947	1,014	1.4
Millet				38	40	1.1	1,722	1,836	1.3
Wheat	4	6	5.1	2	3	6.6	2	2	5.7
Barley									
Other cereals							38	41	1.2
Cassava	345	342	-0.2	127	131	0.6	3	3	1.4
Yam							2	2	1.0
Other roots	183	182	-0.1	151	157	0.9	13	14	1.6
Oil crops	476	535	2.4	628	764	4.0	5,709	6,906	3.9
Pulses	81	92	2.4	511	545	1.3	337	360	1.4
Other crops	7	8	3.0	9	11	3.2	17	21	3.4

Table C.7. Continued

	Mozambique			Nigeria			Rwanda		
	Crop area (1,000 ha)		Annual growth	Crop area (1,000 ha)		Annual growth	Crop area (1,000 ha)		Annual growth
	Current	By 2013	rate (%)	Current	By 2013	rate (%)	Current	By 2013	rate (%)
Maize	1,281	1,308	0.4	5,567	5,848	1.0	127	134	1.1
Rice	175	238	6.3	3,730	4,766	5.0	16	20	4.5
Sorghum	482	512	1.2	8,086	8,505	1.0	250	258	0.7
Millet	75	80	1.2	6,959	7,222	0.7	5	5	1.1
Wheat	1	1	6.4	57	78	6.6	27	33	3.9
Barley									
Other cereals				188	198	1.1			
Cassava	1,909	1,887	-0.2	4,483	4,576	0.4	137	139	0.4
Yam				3,972	4,135	0.8	2	2	0.9
Other roots	17	18	1.1	1,795	1,890	1.0	357	359	0.1
Oil crops	2,692	3,299	4.2	41,109	49,149	3.6	189	236	4.6
Pulses	430	456	1.2	6,604	6,939	1.0	357	378	1.2
Other crops	9	12	6.0	153	198	5.2	8	10	4.2

Table C.7. Continued

	Senegal			Sierra Leone			Tanzania		
	Crop area (1,000 ha)		Annual growth	Crop area (1,000 ha)		Annual growth	Crop area (1,000 ha)		Annual growth
	Current	By 2013	rate (%)	Current	By 2013	rate (%)	Current	By 2013	rate (%)
Maize	147	169	2.8	39	43	2.1	2,036	2,004	-0.3
Rice	113	147	5.5	585	733	4.6	500	618	4.4
Sorghum	186	189	0.4	13	15	2.6	779	809	0.8
Millet	1,291	1,285	-0.1	20	23	2.7	191	200	1.0
Wheat							107	144	6.1
Barley							2	2	2.7
Other cereals	3	3	0.1	3	3	2.4	18	19	0.6
Cassava	42	41	-0.3	75	78	0.9	671	673	0.1
Yam							2	2	0.4
Other roots	2	2	0.3	12	12	1.0	572	588	0.6
Oil crops	3,171	3,731	3.3	403	505	4.6	6,279	7,461	3.5
Pulses	1,432	1,465	0.5	85	99	3.2	810	847	0.9
Other crops	25	29	3.0	1	2	3.6	29	36	4.4

Table C.7. Continued

	Uganda			Zambia		
	Crop area (1,000 ha)		Annual growth	Crop area (1,000 ha)		Annual growth
	Current	By 2013	rate (%)	Current	By 2013	rate (%)
Maize	650	703	1.6	450	462	0.5
Rice	102	133	5.6	11	15	5.5
Sorghum	305	339	2.2	31	35	2.7
Millet	396	428	1.6	45	47	0.9
Wheat	9	12	6.5	21	28	5.5
Barley				2	2	0.6
Other cereals						
Cassava	413	430	0.8	155	152	-0.4
Yam						
Other roots	678	731	1.5	6	6	0.3
Oil crops	3,968	4,788	3.8	1,330	1,562	3.3
Pulses	909	1,005	2.0	32	37	2.7
Other crops	39	47	4.0	7	8	2.8

Table C.7. Continued

	Rest of E. Africa			Rest of S. Africa			Rest of W. Africa		
	Crop area (1,000 ha)		Annual growth	Crop area (1,000 ha)		Annual growth	Crop area (1,000 ha)		Annual growth
	Current	By 2013	rate (%)	Current	By 2013	rate (%)	Current	By 2013	rate (%)
Maize	2,569	2,927	2.6	2,049	2,361	2.9	3,402	3,840	2.5
Rice	630	719	2.7	0	0	2.9	1,363	1,558	2.7
Sorghum	14,598	16,464	2.4	172	198	2.9	6,314	7,106	2.4
Millet	5,844	6,627	2.5	284	322	2.5	8,926	10,043	2.4
Wheat	257	293	2.7	52	60	2.9	13	15	2.8
Barley	60	69	2.7	7	8	2.9	1	1	2.8
Other cereals	13	14	2.2	4	5	2.4	1,316	1,474	2.3
Cassava	2,642	2,951	2.2	47	54	2.5	1,321	1,488	2.4
Yam	110	122	2.2				851	952	2.3
Other roots	312	348	2.2	259	292	2.5	251	282	2.3
Oil crops	15,999	18,100	2.5	3,779	4,353	2.9	21,159	24,076	2.6
Pulses	1,162	1,328	2.7	123	141	2.9	5,830	6,618	2.6
Other crops	93	106	2.6	15	17	2.8	196	224	2.7

Source: Model simulation results.

Table C.8. Crop yield and annual growth rate as the model results

	Angola			Cameroon			Ethiopia		
	Level of yield (mt/ha)		Annual growth	Level of yield (mt/ha)		Annual growth	Level of yield (mt/ha)		Annual growth
	Current	By 2013	rate (%)	Current	By 2013	rate (%)	Current	By 2013	rate (%)
Maize	0.5	0.8	9.3	1.9	2.8	7.7	1.9	2.8	7.8
Rice	1.8	3.0	10.9	2.9	4.3	7.7	1.9	2.9	9.6
Sorghum				1.3	1.9	8.2	1.3	2.0	8.5
Millet	0.4	0.6	7.9	1.1	1.7	8.2	1.0	1.5	8.4
Wheat	1.7	2.9	11.7	1.3	2.6	14.0	1.4	2.5	12.7
Barley							1.0	1.5	8.4
Other cereals	0.0	0.5		0.0	1.6		0.8	1.2	8.4
Cassava	9.6	11.0	2.9	5.5	9.7	12.0			
Yam				7.7	13.7	12.3	4.2	6.4	9.0
Other roots	3.5	3.8	1.5	4.9	6.9	6.8	8.2	13.1	9.7
Oil crops	0.4	0.4	4.0	0.6	0.9	8.8	0.2	0.3	10.6
Pulses	0.2	0.3	6.4	1.1	1.2	2.2	0.9	1.2	5.9
Other crops	0.2	0.3	2.5	1.1	1.2	1.7	0.9	1.0	1.9

Table C.8. Continued

	Ghana			Kenya			Liberia		
	Level of yield (mt/ha)		Annual growth	Level of yield (mt/ha)		Annual growth	Level of yield (mt/ha)		Annual growth
	Current	By 2013	rate (%)	Current	By 2013	rate (%)	Current	By 2013	rate (%)
Maize	1.6	2.7	11.1	1.3	2.2	11.6			
Rice	2.0	3.6	12.2	3.7	5.8	9.2	0.9	1.0	2.2
Sorghum	1.3	2.0	7.9	0.6	1.0	11.1			
Millet	0.8	1.2	8.0	0.4	0.7	10.5			
Wheat				2.5	4.8	14.2			
Barley				2.7	4.4	10.2			
Other cereals	0.7	1.0	7.8	1.0	1.7	10.2	0.9	1.4	8.4
Cassava	12.4	18.2	7.9	11.1	17.9	10.0	6.5	10.5	10.0
Yam	12.5	17.4	6.8	8.4	13.5	10.0	8.7	13.8	9.8
Other roots	5.6	7.5	6.0	8.2	12.3	8.3	9.1	13.4	8.1
Oil crops	0.6	0.9	7.6	0.3	0.5	8.8	1.3	1.5	2.8
Pulses	0.1	0.1	11.7	0.4	0.6	9.5	0.6	0.9	8.1
Other crops	0.1	0.1	1.8	0.4	0.4	2.3	0.6	0.7	2.1

Table C.8. Continued

	Madagascar			Malawi			Mali		
	Level of yield (mt/ha)		Annual growth	Level of yield (mt/ha)		Annual growth	Level of yield (mt/ha)		Annual growth
	Current	By 2013	rate (%)	Current	By 2013	rate (%)	Current	By 2013	rate (%)
Maize	1.8	2.8	9.5	1.1	2.1	13.0	1.0	1.9	14.2
Rice	2.5	3.4	6.5	1.2	2.0	11.7	1.6	2.7	11.0
Sorghum	0.5	0.6	3.3	0.6	1.0	9.1	0.7	0.9	6.9
Millet	2.4	4.5	13.6	0.5	0.7	8.2	0.7	0.9	7.0
Wheat				0.8	1.6	16.4	3.0	5.1	11.5
Barley									
Other cereals	0.0	2.4		0.0	1.1		0.7	1.0	6.5
Cassava	6.2	10.2	10.4	16.3	23.4	7.5	17.9	25.7	7.5
Yam							20.6	29.1	7.2
Other roots	5.5	9.1	10.6	11.9	16.1	6.1	16.5	22.3	6.2
Oil crops	0.4	0.8	12.4	0.4	0.6	6.4	0.3	0.4	6.4
Pulses	1.0	1.2	4.1	0.5	0.7	8.0	0.3	0.5	8.8
Other crops	1.0	1.2	3.0	0.5	0.5	1.6	0.3	0.4	3.0

Table C.8. Continued

	Mozambique			Nigeria			Rwanda		
	Level of yield (mt/ha)		Annual growth	Level of yield (mt/ha)		Annual growth	Level of yield (mt/ha)		Annual growth
	Current	By 2013	rate (%)	Current	By 2013	rate (%)	Current	By 2013	rate (%)
Maize	1.1	1.9	12.1	1.1	1.9	12.6	0.8	1.4	12.6
Rice	1.0	1.7	11.5	1.0	1.8	13.5	3.8	6.0	9.4
Sorghum	0.6	1.0	8.3	1.1	1.8	9.4	0.9	1.3	7.6
Millet	0.5	0.7	8.2	1.0	1.6	9.0	0.8	1.1	7.5
Wheat	1.1	2.3	15.3	1.2	2.3	14.1	0.8	1.4	12.3
Barley									
Other cereals	0.0	0.9		0.5	0.8	9.0	0.0	1.0	
Cassava	6.0	9.6	9.9	9.3	14.7	9.6	5.7	9.6	11.0
Yam				8.6	12.2	7.3	2.7	4.6	11.3
Other roots	9.3	13.5	7.9	5.0	7.3	7.8	6.5	9.5	7.7
Oil crops	0.2	0.4	7.4	0.5	0.8	10.9	0.2	0.3	5.0
Pulses	0.5	0.8	10.4	0.4	0.7	10.4	0.6	0.9	9.2
Other crops	0.5	0.5	1.7	0.4	0.5	1.7	0.6	0.7	1.7

Table C.8. Continued

	Senegal			Sierra Leone			Tanzania		
	Level of yield (mt/ha)		Annual growth	Level of yield (mt/ha)		Annual growth	Level of yield (mt/ha)		Annual growth
	Current	By 2013	rate (%)	Current	By 2013	rate (%)	Current	By 2013	rate (%)
Maize	2.7	3.1	2.7	1.0	1.5	8.0	1.6	2.6	10.3
Rice	2.5	3.7	8.4	1.3	1.9	8.5	1.9	3.2	11.1
Sorghum	0.8	1.3	11.1	1.1	1.3	4.4	1.1	1.7	8.0
Millet	0.5	0.8	10.8	1.0	1.2	4.5	0.8	1.2	8.0
Wheat							1.1	2.3	16.0
Barley							2.3	3.6	9.8
Other cereals	0.4	0.7	10.8	1.1	1.4	4.2	0.8	1.2	7.6
Cassava	6.7	11.3	10.9	5.2	8.1	9.3	10.4	16.6	9.7
Yam							6.5	9.7	8.4
Other roots	21.9	33.6	9.0	2.4	3.8	9.3	2.3	3.7	10.4
Oil crops	0.5	0.7	7.4	1.0	1.2	3.1	0.2	0.3	11.6
Pulses	0.1	0.1	11.4	0.7	0.9	4.8	0.6	1.0	11.0
Other crops	0.1	0.1	2.7	0.7	0.9	4.5	0.6	0.7	1.9

Table C.8. Continued

	Uganda			Zambia		
	Level of yield (mt/ha)		Annual growth	Level of yield (mt/ha)		Annual growth
	Current	By 2013	rate (%)	Current	By 2013	rate (%)
Maize	1.8	2.8	9.0	1.9	2.9	8.3
Rice	1.5	2.6	11.2	1.2	1.9	10.2
Sorghum	1.5	2.2	8.6	0.6	0.9	8.8
Millet	1.7	2.5	8.1	0.7	0.9	6.9
Wheat	1.7	3.3	14.9	6.4	9.0	7.0
Barley				0.9	1.3	6.6
Other cereals	0.0	1.7		0.0	1.9	
Cassava	13.5	21.9	10.2	5.8	9.3	9.9
Yam						
Other roots	4.7	6.6	7.1	13.3	19.7	8.2
Oil crops	0.3	0.4	7.9	0.2	0.3	8.1
Pulses	0.7	1.1	9.2	0.5	0.9	12.1
Other crops	0.7	0.8	3.0	0.5	0.6	2.3

Table C.8. Continued

	Rest of E. Africa			Rest of S. Africa			Rest of W. Africa		
	Level of yield (mt/ha)		Annual growth	Level of yield (mt/ha)		Annual growth	Level of yield (mt/ha)		Annual growth
	Current	By 2013	rate (%)	Current	By 2013	rate (%)	Current	By 2013	rate (%)
Maize	0.8	0.9	1.4	0.5	0.6	1.1	1.1	1.1	1.1
Rice	0.9	1.0	1.4	2.6	2.7	1.1	1.9	2.1	1.3
Sorghum	0.4	0.5	1.2	0.7	0.7	1.1	0.6	0.6	1.0
Millet	0.2	0.2	1.2	0.3	0.3	0.8	0.5	0.5	1.0
Wheat	2.3	2.5	1.4	3.0	3.1	1.1	1.0	1.1	1.3
Barley	0.2	0.2	1.4	4.3	4.6	1.1	2.0	2.1	1.3
Other cereals	0.8	0.9	0.9	0.8	0.9	0.6	0.5	0.5	0.9
Cassava	8.1	8.5	1.0	4.4	4.5	0.7	6.8	7.1	0.9
Yam	3.0	3.1	0.8				10.2	10.7	0.8
Other roots	8.2	8.6	0.9	2.3	2.4	0.7	5.0	5.3	0.9
Oil crops	0.3	0.4	1.2	0.2	0.3	1.1	0.5	0.5	1.2
Pulses	0.8	0.9	1.4	0.7	0.7	1.1	0.3	0.3	1.1
Other crops	0.8	0.9	1.3	0.7	0.7	1.0	0.3	0.3	1.3

Source: Model simulation results.
Note: mt = metric ton.

Table C.9. Sensitivity test: Total change in producer prices (% change from the base, averaged over 17 countries, 2008–2013)

	Testing alternative supply elasticities			Testing alternative income elasticities		
	50% lower	Simulation 1	50% higher	25% lower	Simulation 1	25% higher
Maize	-34.9	-33.2	-29.9	-35.1	-33.2	-27.0
Rice	-12.5	-12.1	-11.2	-20.1	-12.1	-5.1
Sorghum	-30.2	-29.1	-27.1	-31.2	-29.1	-23.8
Millet	-34.0	-32.8	-28.9	-34.7	-32.8	-25.5
Wheat	-20.3	-19.5	-17.9	-28.3	-19.5	-5.7
Barley	-47.3	-47.3	-44.3	-47.3	-47.3	-37.6
Other cereal	-43.4	-43.4	-39.5	-43.4	-43.4	-33.9
Cassava	-37.4	-34.5	-29.9	-37.7	-34.5	-27.6
Yams	-41.1	-38.7	-33.8	-41.1	-38.7	-32.1
Other roots	-43.3	-42.3	-38.4	-43.4	-42.3	-33.8
Oil crops	-29.7	-29.0	-27.9	-32.0	-29.0	-24.2
Pulses	-31.0	-30.3	-28.0	-34.0	-30.3	-21.9
Other crops	-3.8	-6.1	-6.3	-14.7	-6.1	4.4
Poultry	-4.2	-5.9	-6.2	-13.2	-5.9	0.6
Other livestock	-8.5	-10.0	-9.7	-17.2	-10.0	-1.7
Average difference from simulation 1	*-0.49*		*2.34*	*-3.94*		*7.95*

Source: Model simulation results.
Note: Simulation 1 is the simulation without market integration.

Table C.10. Current level of public spending on agriculture and national poverty rate

	Current public spending on agriculture in constant 2008 $US million	Share in total spending (%)	Headcount poverty rate in 2007 (%)
Angola	n/a		52.0
Cameroon	107	3.8	28.7
Ethiopia	360	13.6	38.9
Ghana	119	6.7	28.2
Kenya	174	4.2	61.3
Liberia	n/a		28.7
Madagascar	9	1.6	87.7
Malawi	22	2.7	64.6
Mali	205	14.5	61.2
Mozambique	66	4.0	41.7
Nigeria	934	3.2	77.4
Rwanda	21	4.0	67.2
Senegal	88	4.4	57.2
Sierra Leone	8	3.1	77.4
Tanzania	115	4.4	37.9
Uganda	99	5.0	29.4
Zambia	44	2.7	66.1
Rest of E. Africa	9	3.0	52.0
Rest of S. Africa	161	4.3	30.0
Rest of W. Africa	646	6.7	30.0

Source: Government finance statistics of the International Monetary Fund (IMF), supplemented by statistical appendix and poverty reduction strategy papers. The definition of agricultural expenditure is the standard definition used by the IMF in the GFS Manual (2001). Public spending on agriculture and total spending are updated to 2007 at 2008 U.S. dollars using historical trends. Poverty rates are also updated using trends.

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